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MAKING VISION REALITY:

PREPARING THE AIR FORCE TO EXPLOIT FUTURE TECHNOLOGY

by

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The Air Force faces significant reductions and restructuring of the research, development, test and evaluation (RDT&E) infrastructure. The Air Force needs to assess how best to cope with the reductions and insure future vital technology is developed and tested. This paper reviews the Air Force?s commitment to technology by examining historic trends. The trends include funding and manning levels, and a subjective assessment of the Air Force approach to technology. The subjective assessment includes five rating areas. For example, the study examines whether the Air Force was more committed to revolutionary technology or incremental improvements to current technical capabilities during various timeframes. In addition, the recommendations of two major scientific studies by the Scientific Advisory Board, Toward New Horizons and New World Vistas, are examined. From this historical analysis, recommendations are made concerning the changes in Air Force strategy and policy for RDT&E.

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Preface

The history of the Air Force's research, development, test and evaluation capability is an intriguing subject. The Air Force has always professed a love of technology and avows to embrace technology more than the other Services. Recent budget and personnel pressures have put the scientific and test community within the Air Force at risk. Many briefings and studies have shown the wisdom of protecting the research, development, test and evaluation manning, budgets, and infrastructure from harm. These briefings usually showed the greatest impacts possible. Budget reductions were computed from the highest funding year, as was manning. This study attempts to set a broader historical perspective for analyzing trends. The study is both objective and subjective, and may generate some healthy debate. There needs to be a debate on the Air Force strategic approach to science and technology. Today's metric and business practice mindset is troubling. Businesses are interested in profit and loss and return of investment; this short-term mindset is not appropriate for an Air Force science and technology strategy.

I would like to give special thanks to my advisors, Dr. William Martel and Col (Ret) Theodore Hailes for their help and advise. I would also like to thank the members of the Technology and Strategy elective course at Air War College, whose spirited discussions of strategy and technology issues helped form my approach to this topic.

Abstract

The Air Force faces significant reductions and restructuring of the research, development, test and evaluation (RDT&E) infrastructure. The Air Force needs to assess how best to cope with the reductions and insure future vital technology is developed and tested. This paper reviews the Air Force's commitment to technology by examining historic trends. The trends include funding and manning levels, and a subjective assessment of the Air Force approach to technology. The subjective assessment includes five rating areas. For example, the study examines whether the Air Force was more committed to revolutionary technology or incremental improvements to current technical capabilities during various timeframes. In addition, the recommendations of two major scientific studies by the Scientific Advisory Board, *Toward New Horizons* and *New World Vistas*, are examined. From this historical analysis, recommendations are made concerning the changes in Air Force strategy and policy for RDT&E.

Chapter 1

Introduction

> *The rate of technological change has accelerated and the nation's future force must keep pace to maintain its military edge. We must reinvigorate the spirit of innovation and creativity that has long been the hallmark of the United States Air Force.*
>
> — Global Engagement: A Vision for the 21st Century Air Force

The Air Force is arguably the most technologically oriented Service. Born of a new technology, the Air Force has placed enormous faith in advancing technology as a mainstay of increasing the nation's airpower. One needs look no further than the Gulf War to see the tremendous benefits and impacts of the technologies enabling stealth aircraft, precision strike, and theater command and control, to name only a few. But, the decline in force structure since the Gulf War has placed the role of technology at the forefront for the future Air Force. Perhaps as never before, the Air Force will need to maximize the output of the technology developed in its research, development, test and evaluation (RDT&E) infrastructure. Is the Air Force taking the right course to meet the needs of the future force? Does the Air Force have the proper commitment to technology development to meet the needs of air and space warriors in the future? What are the key factors to measure the relevancy of the Air Force's approach and investment in RDT&E?

Answering the above questions is extremely difficult. R&D programs started today may not show an effect for ten years or more. In this age of "metrics" for real time

measurement of accomplishment, the true value of the Air Force's RDT&E program can be lost or understated.

This effort will examine the history of Air Force RDT&E in order to form a baseline against which the present status will be examined and recommendations made concerning potential refocusing of Air Force policies and strategies. The analysis will consider both statistical data and subjective analysis. The statistical data includes funding and manning trends in research and development. The subjective analysis will examine several factors as a "report card" for summarizing the Air Force philosophy during different historical periods. The factors provide a continuum view of the Air Force's approach and strategy for technology development from the beginning of the Air Corps to the present day. Based on an examination of these factors, this paper will present recommendations for potential refocusing of Air Force RDT&E policies and strategies in the future.

The factors selected provide a framework for examining and thinking about the RDT&E strategy the Air Force has pursued over the years. The factor "pairs" are:

Innovation……………………………………………………..Efficiency
Revolution……………………………………………………..Improvement
Capability………………………………………………………Threat
Independence…………………………………………………..Reliance
Vision…………………………………………………………..Requirements

Innovation versus efficiency. Innovation and efficiency refer to the overall focus of RDT&E philosophy. Is research being directed towards innovative technologies to improve overall system performance? Is research more focused on improving efficiency of production and reducing costs? Are investments being made to improve the technology for future systems, or to improve the efficiency of current laboratory technologies and test centers to reduce costs? In this context, efficiency should not be

confused with the concept of spending money wisely or using manpower efficiently. Efficient mission accomplishment is always a priority.

Revolution versus improvement. Revolution and improvement relate to the philosophy of asymmetric systems development versus making incremental improvements in systems. The Scientific Advisory Board (SAB) defined revolutionary system development in the report *New World Vistas* as follows:

> Nearly always, it is the evolutionary follow-on of a new concept that produces a revolution in capability. For example, the nuclear weapon was the most revolutionary weapon ever invented. It not only changed the nature of warfare but also it changed the nature of all interactions among nations, and it changed the way all science was viewed by the public. The first two nuclear weapons, however useful as a demonstration of the principle, would not, had they been duplicated many times, have had that affect. It was the evolutionary development of the thermonuclear weapon from the fission weapon coupled with the evolution of the ICBM from the V-2 that produced the profound effects on society.[1]

Producing a revolution in technology can lead to an evolutionary weapon, and thus provide an asymmetric capability. Another example would be stealth technology. Stealth could be considered a revolutionary technology that, when coupled with improvements to current aircraft technology, produced an asymmetric weapon system.

Improvement refers to incremental steps in technology development. The advancement in fighter design from the 1950s to the 1980s would be an example. For example, F-15s and F-16s are fundamentally incremental improvements in technology over F-4s and F-105s. Improvements in aircraft design, avionics, engines, and other systems have been increments of previous technologies rather than revolutionary steps. Again, this is not an absolute. The revolution in computing power brought on by microchip technology is imbedded in this example. But, considered as a whole, the latest generation of fighters, and the F-22, are incremental system improvements.

Capability versus threat. Capability versus threat is closely related to revolution versus improvement. Capability versus threat is the forcing function. Is there an opportunistic approach to technology (capability)? Is there a specific or perceived threat driving technology? Either approach could result in a revolutionary or incremental system. In very simplistic terms, capability is "we can", threat is "we must".

An example from Soviet history illustrates the capability and threat issue vividly. In the early 1960s, the Soviet Union made a critical decision affecting their future capability. The Soviet Academy of Sciences disbanded its computing division, and assigned the scientists to more near-term efforts, such as designing new weapon systems. In early 1960s, Soviet computing capability was close to Western standards. By the mid-1980s, the Soviet Union was two generations behind the West in computer technology and falling further behind.[2]

Independence versus reliance. Independence and reliance refer to the "how" of pursuing technology. An independent approach would have the Air Force doing most technology development "in house" with the test facilities to validate performance. In addition, it refers to the ability of the Air Force to set its own technology agenda independently. At the reliance end of the spectrum, the Air Force would be more dependent on others, such as contractors, universities, and the other Services for technology development, and would require more coordination and support from other agencies to set a technology agenda.

Vision versus requirements. Finally, vision versus requirements refers to the overall guiding philosophy of the Air Force RDT&E effort. Is the effort more focused on a long-range vision of the Air Force of the future, or is it based on the more near-term needs? In

this context, a requirement is a defined shortcoming in technology. A visionary approach provides a general "heading" for technology to pursue for the long-term.

None of these factors are necessarily better than the other factors. Vision is not better than requirements. No one would want a completely visionary approach to technology that ignores present requirements. Likewise, it would be foolhardy to ignore present threats to pursue capabilities only because we can. On the other hand, being tied too closely to threat based development may veil potential breakthroughs that provide a revolutionary or asymmetrical capability. The interaction, balance, and trends as proposed by this study reflect judgments of an analysis of the known history. The factors and the individual ratings are debatable, but the reader should keep in mind this study focuses on broad trends.

Defining Key Concepts

It is important to define several key concepts. The RDT&E infrastructure is the first key concept, which is defined as people (intellectual capital), facilities, and funding. Engineers, scientists, and innovators are needed to generate the basic ideas and give these ideas life. Certainly, not all of these people need to be Air Force personnel. In fact, a congressional study contends that the Air Force contracts out more research than the other Services.[3] But there must be a core of Air Force personnel, military and civilian, to both perform some in-house research and serve as the leaders and integrators of all Air Force research efforts.

RDT&E facilities are needed to perform basic research and to test the fundamental concepts and prototypes. Facilities include the typical "lab bench", to supercomputers for computational fluid dynamic simulations, to wind tunnels, to open air ranges, and all

types of facilities in between. Again, not all facilities belong to the Air Force. Indeed, the legacy of Base Realignment and Closure (BRAC) and the potential for future actions would suggests that even fewer facilities will belong to the Air Force. But facilities are to proving new concepts at the level needed for the development of advanced technologies.

Funding is the third piece of this triad. The importance of adequate, stable funding for research and development is self-apparent. As mentioned above, the Air Force procures much of its research from private firms or universities. Continued innovation depends on a stable funding strategy for technology efforts within the Air Force and in the research community at large.

It is important to revisit the concept of vision. If unconstrained budgets and time were available, vision would not be a particularly important concept. Research could be conducted at its own pace, across a broad front of potential technological areas. The realities of constrained budgets and time require a more deliberate approach to conducting research and development. A visionary guiding statement of objectives is needed to help steer research efforts toward the technologies believed to be most important for the future Air Force. Two such statements – *Toward New Horizons* and *New World Vistas* – will serve as the pillars of this study. These two documents, both generated by the Air Force Scientific Advisory Board, are the significant guiding vision documents for the Air Force. *Toward New Horizons*, published in 1945, served as the impetus for the technology development in the new Air Force after World War II. *New World Vistas* was published 50 years after *Toward New Horizons*, provides the

technological vision for the future Air Force. Suffice it to say, a vision must be broad enough to allow innovation, yet specific enough to guide resource emphasis.

As previously mentioned, technology is a force multiplier and is one of the factors that allows the United States to be a superpower with a relatively small military, even though the U.S. military will continue to shrink in the near future. The currently programmed reductions to the Air Force from fiscal years 1985 to 2003 are: [4]

1. Aircraft purchased reduced by 73 percent.
2. Major installations overseas reduced by 68 percent.
3. Intercontinental Ballistic Missiles (ICBM) reduced by 47 percent.
4. Active military end strength reduced by 38 percent.
5. Civilian end strength reduced by 38 percent.
6. Aircraft reductions reduced by 29 percent.
7. Major installations in the U.S. reduced by 26 percent.

Although currently the United States is without peer in the technology of its military systems, we cannot rest on these achievements for long. More technology is available on the world marketplace than ever before. The breakup of the Soviet Union has provided nation states the opportunity to buy Soviet technology and entice Soviet scientists and engineers to continue their work under another flag. The worldwide computer and communication revolution has fostered technological advances that may make computer keyboards as much of a weapon as bombs and bullets. The United States must stay on the forefront of technology to ensure our national security. The Air Force's strategic vision and approach to technology development will be a key determinant in how the Air Force of the future continues to do its part in providing national security.

As a final note, it is important to stress that this study will examine the above in terms of trends, not absolutes. The focus is concepts and directions to provide guidance for the future.

Notes

[1] Scientific Advisory Board, *New World Vistas, Summary Volume*, (Washington, DC: Scientific Advisory Board, December 1995), 13.

[2] Donald M. Snow and Eugene Brown, *Beyond the Water's Edge*, (New York, NY: St. Martin's Press, Inc., 1987), 68.

[3] U.S. Congress, Office of Technology Assessment, *Defense Conversion: Redirecting R&D*, OTA-ITE-552 (Washington, DC: U.S. Government Printing Office, May 1993), 147.

[4] HQ USAF/PES briefing, Dec 1996.

Chapter 2

The Early Years of Air Force Research

The idea that aviation, acting alone, can control sea lanes, or defend the coast, or produce decisive results in any other general mission contemplated under our policy are all visionary, as is the idea that a very large an independent air force is necessary to defend our country against air attack.

-- Report of Secretary of War Newton D. Baker, 1934

Aviation research and development had its beginnings long before there was a separate Air Force. The United States Army established an aeronautical division within the Signal Corps by 1907. From 1907 to the beginning of World War I, the federal government spent approximately $435,000 on aeronautical development, but during this same time period, however, Germany spent $28 million. Countries such as Belgium, Japan, China, Bulgaria, Greece, Spain and Brazil all spent more on aeronautical research than did the United States.[1]

The advent of World War I highlighted the shortcomings of U. S. aeronautical development. Congress, in an effort to catch up to European nations, appropriated $5,000 for the National Advisory Committee for Aeronautics (NACA) as a permanent national body of experts for the advancement of aviation research. A military counterpart to the NACA was established at McCook Field, Ohio in 1917. Despite these efforts, the

U.S. entered World War I without a single aircraft design ready for production, and used British and Italian designs in its production facilities.[2]

The United States government did not enjoy a robust aeronautical research and development program in the years between World War I and when war began in 1940. From 1925 until 1937, the federal aviation annual research budget hovered between $2-$4 million. The research and development organization at McCook Field gradually evolved into three engineering categories: experimental, production and maintenance. The McCook Field activity grew from an original cadre of approximately 1,400 to over 2,000 by 1939, and experienced the growing pains of any new organization that is grappling with a radically new technology.[3]

In contrast, commercial industry performed the lion's share of U.S. research and development in the inter-war years. Industry spent almost $100 million each year in the late 1930s on aviation research.[4] In terms of infrastructure and personnel, in 1938 1,750 corporations maintained 2,237 research laboratories staffed by 44,292 personnel.[5] Commercial firms were eager to exploit this new technology, and led the way in terms of technology breakthroughs and new aircraft developments.[6]

In the 1930s, aviation technology was proceeding quite rapidly. In 1934, the first line longevity of Air Corps models was six years for pursuit, attack and bomber aircraft. By 1939, the first line longevity was estimated a four years for pursuit, five years for attack and medium bombers, and six years for heavy bombers.[7] Observation and transport aircraft showed similar trends. In 1935, the War Department believed that the U.S. had an air force equal or superior to any in the world. Unfortunately for the U.S., by 1939, the majority of aircraft were obsolete or close to it. This situation in part would be

due to the inadequacies of the R&D program, which had been shaped by three fundamental factors. The first factor was that national policy was based on the assumption that America would fight a strictly defensive war. A second factor was the uncertain delineation of responsibilities between the two services for defense of the immediate approaches to the United States. Finally, the limited funding available was also a key factor in the R&D program debate.[8]

Despite national policy and inter-Service debates, the Air Corps did win the battle to develop a long-range bomber. Long-range strategic bombing had become the cornerstone of Air Corps philosophy as reflected in documents such as the Air Warfare Planning Document (AWPD-1). Development of a strategic bomber would be the principle R&D activity funded by the Air Corps R&D efforts. The proof can be seen in reviewing the status of the Air Corps in 1939. Of all the aircraft in the inventory in September 1939, only the B-17 actually flew as a first-line aircraft in World War II.[9] To be sure, all the aircraft now familiar to us – the P-47, P-38, P-51, B-26, etc. – were all on the drawing boards at the beginning of World War II. While development of escort fighters in particular was accelerated during the war, a case could be made that perhaps too much of the limited pre-war Air Corps R&D funding had been placed against the vision of the long-range bomber.[10]

Furthermore, other nations were making greater investments in technology than the U.S. While the U.S. concentrated on traditional piston engine designs, Germany and Britain were rapidly closing in on the jet age. Germany in particular spent great sums to develop jet propulsion. As Table 1 shows, Germany's wartime use of jet aircraft was the result of years of research and development prior to the war. U.S. development of jet

propulsion would never really catch up, and depended in large part on technology from Great Britain.[11]

Table 2. Timetable of Turbojet Development

YEAR	GERMANY	BRITAIN	USA
1936	First Design Heinkel jet engine		
1937		First jet engine running	
1938	First run on Heinkel jet engine		
1939	First flight He 178	Contract for jet fighter by RAF	
1940	First run on Ju 004 and BMW 003 jet engines		
1941		First flight "Squirt"	Gen Arnold directs British development to U.S.
1942	First flight, Me 262 with two Ju 004 jet engines	First engine sent to U.S.	First flight jet plane
1943			
1944	First use Me 262. Start of large scale production	Experimental series	Experimental series
1945			

Research and Development in World War II

Air Corps research and development in World War II reflected the prewar years in many aspects. The basic organizational structure and manning remained essentially the same, although the organization would shift among various command structures. The big changes from the prewar years were in focus and funding.

Research and development "vision" was very near-sighted during World War II. Although behind other nations in the capability of most fielded aircraft, the U.S. had a number of competitive designs at the beginning of World War II which were rushed into production. Early in the war, the industry R&D cadre was pressed into service to "jump start" the massive production lines which would fuel the war effort. In addition to being behind in first-line aircraft models, the U.S. lacked the immediate industrial capacity to produce the massive quantities of war goods required.[12]

General Henry "Hap" Arnold realized there was little time to waste, and ordered improvements that could be implemented on production line aircraft were to take precedence. Improvements such as auxiliary bomb racks, leak-proof fuel tanks, and de-icing equipment were given priority over longer-range technology. Most of the cutting edge technology, such as sonar and radar, would be the result of British research efforts.[13] There would be few exceptions to the requirement for near-term research solutions that could impact systems within six to eighteen months. General Arnold did make an exception for jet engine development.

General Arnold was instrumental in bringing jet engine technology to the United States. As Table 1 shows, General Arnold brought a British jet engine to the U.S. in 1941. General Arnold allowed development efforts to continue, even though he did not believe that allied jet aircraft would be fielded in time to affect World War II. General Arnold was already looking to the future, and would continue to look far into the future even before World War II had ended.

The second area that changed from prewar days was funding for research and development efforts. As Table 2 shows, funding for the Army Air Forces R&D efforts

increased dramatically.[14] Arguably, much of the funding could be considered production enhancements rather than true research and development. As noted previously, most of the prewar aviation research infrastructure resided in industry. Thus, roughly 80 percent of the World War II R&D funding went to industry.[15]

Table 3. Army Air Forces Wartime R&D Appropriations

1939	$3,574,290
1940	$10,000,000
1941	$102,231,275
1942	$98,198,615
1943	$113,342,636
1944	$121,647,605
Total	$449,994,421

The Army Air Force also took advantage of the increased funding levels to add new facilities during this time to test the new systems and subsystems being developed. Most notable of the new facilities were the munitions testing range at Valparaiso, Florida (later to become Eglin AFB) and the expansion of testing at Muroc Dry Lake Bed, California (now Edwards AFB). These sites offered the isolation, security, good weather, and uncrowded airspace to test a rapidly growing number of new munitions and aircraft systems and subsystems. In addition, investments were made in the facilities at Wright Field, as capital investment increased from $10 million in 1939 to nearly $54 million in 1944.[16] This expansion would continue after World War II, as will be seen in the next section.

Summary

Reviewing the approach and philosophy in the inter-war period, the scorecard for the Air Corps approach is:

Innovation……**X**…………………………………………..Efficiency
Revolution……………………………………**X**………..Improvement
Capability………**X**…………………………………………Threat
Independence…………………………………..…..**X**….Reliance
Vision…………**X**…………………………………………Requirements

The Air Corps pressed for innovations in the inter-war years. More powerful aircraft engines and aircraft designs, for example, and were less concerned with technologies for the production of systems. The obsolescence cited earlier showed the effects of a highly innovative period in aircraft evolution.

The Air Corps was fundamentally pressing for improvements in current technology rather than a revolution. The revolutions were taking place overseas in Germany and Britain. Severely constrained by budgets, manpower, and organizational structure, the Air Corps pressed for improvements that were possible in the known piston engine and aircraft technology of the day.

Capability definitely dominated Air Corps thinking in the inter-war years. With a national strategy of only fighting a defensive war and air power still in its infancy, there was no threat to drive technology development. The Air Corps was most interested in pursuing the technological capability to make long-range strategic bombing a reality.

With few people, low funding, meager facilities and functionally aligned within the Army, the Air Corps had to rely on other organizations for technology development and support for Air Corps technology philosophy. As noted earlier, industry investments and facilities far outweighed those of the Air Corps. The significant investments in industry,

NACA, and university research – conducted independent of Air Corps funding or direction – were vital to the advancements in aircraft technology. The Air Corps vision of large, long range strategic bombers were complimentary to industries' desire to develop large commercial transport aircraft. Thus, the Air Corps could benefit from much of the industry investment.

Finally, the Air Corps technology approach was driven by a vision for the future. The steadfast belief in the role of air power for the future, most notably long-range strategic bombardment, set a vision that fueled the Air Corps to develop the technology to make it a reality. The press of requirements during World War II would temper this vision only slightly.

A dramatic shift in focus is clearly evident with the onslaught of World War II:

Innovation……………………………………………**X**……..Efficiency
Revolution………………………………………………**X**…..Improvement
Capability……………………………………**X**……………Threat
Independence………………………………**X**………..…..….Reliance
Vision…………………………**X**…………………………Requirements

The shift in priorities is dramatic and understandable. The country had to mobilize all of its assets to fight a two front war in Europe and the Pacific. Research and development shifted to the needs of a production-based war effort. Pre-war aircraft designs were rushed to production and modified throughout the war. The notion of strategic bombers "always getting through" proved fatal in the skies over Germany, and the escort fighter was born to counter a very real threat.

The Army Air Force was beginning to achieve some measure of independence. The AAF had a greater voice within the War Department through great leaders such as

General Hap Arnold. In addition, significant increases in R&D funding were beginning to give the AAF greater inherent capabilities to develop and test technologies.

The pre-war vision of strategic bombardment provided strong guidance during the war. This vision was tempered, however, by the vast World War II requirements. Research and development had to be channeled into addressing production requirements and near-term modifications.

There are numerous ways to assess the period between World War I until almost the end of World War II. In terms of personnel, the Air Corps R&D cadre had grown slightly over the years, and had been moved from command to command, but had not fundamentally changed. The industrial cadre, however, had grown significantly between World War I and World War II, and would contribute significantly to aircraft R&D.

With regard to facilities, the primary focus for R&D efforts had stayed at Wright Field, after a short move from McCook Field in the 1930s. New test facilities had been added at Valparaiso, Florida and Muroc Dry Lake Bed, California for testing munitions and aircraft, respectively. Industry and NACA had the bulk of laboratories and test facilities for the development of new aircraft.

Poorly funded during the 1930s, Air Corps R&D had depended heavily on industry efforts and NACA to make many of the advances in aviation technology. Of the advances most directly supported by the Air Corps, the research influencing the development of the strategic bomber was certainly the most prominent vision guiding development efforts. The infusion of funding during World War II was dedicated primarily to near-term efforts to improve fielded systems.

While Air Corps R&D would provide other weapon enhancements during the war, the evolution of the strategic bomber would be the key contribution. Most of the other significant technological advances occurred due to extraordinary cooperation between military and civilian organizations. The most celebrated of these teaming achievements was the Manhattan Project for the development of the atomic bomb.[17]

The Air Corps pursued improvements in systems with the available resources in personnel, infrastructure and funding. Germany had shown the impact of revolutionary development of potential asymmetric threats, through the V-1 and V-2 rockets, and the ME-262 jet fighter. These were glaring examples of how technology could shape wars. This lesson was not lost on General Hap Arnold, and he was determined to chart the course of the future Air Force even before the last shot of World War II had been fired.

Notes

[1] Michael H. Gorn, *Vulcan's Forge. The Making of an Air Force Command for War Acquisition (1950-1986) Volume I* (Andrews Air Force Base, MD: Office of History, Headquarters Air Force Systems Command, 1986), xiii.

[2] Ibid.

[3] Ibid.,xiv.

[4] Ibid.

[5] Wesley Frank Claven and James Lee Cate, *The Army Air Forces in World War II, Volume VI: Men and Planes* (The University of Chicago Press: Chicago IL, 1955), 181.

[6] Donald Baucom, *Air Force Images of Research and Development and Their Reflections in Orgranizational Structure and Management Policies*, Doctoral Dissertation, University of Oklahoma (Norman, OK: 1976), 2-5.

[7] Claven and Cate, *The Army Air Forces in World War II, Volume VI: Men and Planes*, 177.

[8] Ibid.

[9] Ibid., 175.

[10] Ibid., 241.

[11] Theodore Von Karman, Army Air Forces Scientific Advisory Board, *Where We Stand* (Wright Field, OH: May 1946), 25.

[12] Claven and Cate, *The Army Air Forces in World War II, Volume VI: Men and Planes*, 182-185.

[13] Gorn, *Vulcan's Forge. The Making of an Air Force Command for War Acquisition (1950-1986) Volume I.* xv.

Notes

[14] Gorn, *Vulcan's Forge. The Making of an Air Force Command for War Acquisition (1950-1986) Volume I.* xv-xvi.

[15] Claven and Cate, *The Army Air Forces in World War II, Volume VI: Men and Planes*, 240.

[16] Ibid.

[17] Baucom, *Air Force Images of Research and Development and Their Reflections in Organizational Structure and Management Polices, 8-10.*

Chapter 3

Dawn of a New Age

General Hap Arnold was a man of vision. Before World War II was at an end he was paving the way for the new U.S. Air Force he knew would come in the not too distant future. Part of his vision was to insure that the Air Force would be at the forefront of new technology. One of the harsh lessons apparent from World War II was how far behind the U.S. had been in terms of aeronautical technology. Germany clearly had the lead in jet and rocket propulsion. Britain had been at the forefront for radar and sonar. General Arnold realized that the new Air Force must be at the forefront of technology to be pre-eminent. To address the requirements for a post-World War II Air Force RDT&E infrastructure, General Arnold turned to Dr. Theodore von Karman and the Scientific Advisory Group (later to become the Scientific Advisory Board).

General Arnold tasked Dr. von Karman and his colleagues to examine current research efforts and prepare a report outlining a recommended future for Army Air Forces research and development programs.[1] The series of reports Dr. von Karman's group generated were called *Toward New Horizons*.

The first report, titled *Where We Stand*, examined German development efforts and postulated some fundamental realities of future air warfare. Dr. von Karman's report found German strengths in rocketry, jet engines, wind tunnels, and supersonic aircraft

design. German successes were due to two factors. First, the Germans had made large investments in the latest test equipment. Supersonic wind tunnels, for example, had been built in Germany many years in advance of any planned in the United States. These tunnels and other investments made substantial contributions to German supersonic aerodynamic research.[2] Second, the Germans used a unified research organizational structure that contained the expertise required for the technology being developed. Furthermore, the study found that the Germans were weak in radar and electronics, and concluded that they had failed to exploit university expertise in these areas.[3] Based on the Committee's review of aviation technology in the U.S. and Europe, a list of "fundamental realities" was presented to General Arnold:[4]

1. Aircraft, manned or pilotless, would move with speeds far beyond the velocity of sound.
2. Due to improvements in aerodynamics, propulsion, and electronic control unmanned devices would transport means of destruction to targets at distances up to several thousands of miles.
3. Small amounts of explosive materials will cause destruction over areas of several square miles.
4. Defense against present-day aircraft will be perfected by target-seeking missiles.
5. Only aircraft or missiles moving at extreme speeds will be able to penetrate enemy territory protected by such defenses.
6. A perfect communication system between fighter command and each individual aircraft will be established.
7. Location and observation of targets, take-off, navigation and landing of aircraft, and communication will be independent of visibility and weather.
8. Fully equipped airborne task forces will be enabled to strike at far distant points and will be supplied by air.

In the report *Science, the Key to Air Supremacy*, Dr. Von Karman reviewed the status of technology development and reached a number of conclusions. These conclusions ranged from the impact of atomic weapons to recommendations for a systematic approach to developing and testing new technologies.[5]

Dr. von Karman and his associates also studied the use of scientific knowledge in World War I and World War II. World War I, they reasoned, had relied on human endurance to determine a victor. World War II had linked technology and science to military objectives. Furthermore, their investigations argued that years of scientific research were required before development could be undertaken. Therefore, Dr. von Karman lobbied for either a separate institution for R&D, or a supervising R&D agency attached to the Office of the AAF Chief of Staff.[6]

Another recommendation related to funding for research and development. Dr. von Karman reasoned that the cost of research and development should be related to one year's expenditures on air warfare. The proposed goal was a peacetime R&D budget that equated to five percent of the budget for one year of war. Given that peacetime budgets would roughly be 15-20 percent of wartime spending, the amount recommended for R&D would constitute 25-33 percent of the Air Force budget![7]

Thus, Dr. von Karman provided some key principles for General Arnold to work with: form a cadre of science and engineering that included strong uniformed presence; develop close ties with the university community to compliment the ties to industry forged in World War II; and tap the leading edge of research in the country. He envisioned the need for an organizational structure that placed R&D on a footing with other major Army Air Force commands. While Dr. von Karman's budget suggestions were unrealistic, the requirement for increased funding levels based on the broad front of technological visions proposed in *Toward New Horizons* was unmistakable.

General Arnold was delighted with *Toward New Horizons* and many of Dr. von Karman's recommendations. General Arnold ensured that *Toward New Horizons*

received wide distribution, and worked for acceptance of the effort within the Army Air Force staff. General Arnold wanted to use *Toward New Horizons* as a blueprint, and many of Dr. von Karman's recommendations became policy in 1946.[8] General Arnold's attempts to institutionalize *Toward New Horizons* would be frustrated by a number of factors after the end of World War II.

Post World War II Trials and Tribulations

The turmoil of post World War II would prove too difficult to implement the vision of Dr. von Karman and his cohorts. The post war era brought rapid changes that overwhelmed the planned revisions in the Army Air Force R&D infrastructure and philosophy. In time, many of the original recommendations would come to fruition in one form or another. But the post war era before the United States Air Force came into being proved to be an interesting period, nevertheless.

Organizationally, General Arnold initially established the Deputy Chief of Staff for R&D (DCS/R&D) in 1946. By October 1947, however, the position had been eliminated and R&D had been absorbed back into the DCS, Materiel. The position simply did not have the span of control or the necessary oversight of R&D efforts to function as an effective voice for the research and development organizations.[9] In addition, the support for R&D was not particularly strong beyond General Arnold.

The Army Air Force, soon to be the U.S. Air Force, had a difficult time institutionally dealing with the role of R&D. Many within the Army Air Force identified more with being a combat arm rather than a separate Service. As such, they were more concerned with the status of systems on hand and how to make them incrementally better rather than thinking about the future of air power. Even though German aeronautical

developments had presented asymmetric threats in the skies over Europe, many Army Air Corps officers apparently did not see the advantages of pursuing asymmetric systems for the future.[10]

Furthermore, the post war Army Air Force would have to create an air power force to support national security objectives in a rapidly demobilizing force. The Army Air Force demobilized from 2.2 million at the end of World War II to 485,000 by April 1946. That number would drop to 303,000 by May 1947.[11] This free fall in manpower was mirrored in budgets and equipment, which left little room or sympathy for the R&D organizations.

Birth of the U.S. Air Force and a new command for R&D

As part of the National Security Act of 1947, a separate U.S. Air Force was established. One of the first taskings from President Truman to the new Secretary of the Air Force, Thomas Finletter, was to provide an assessment of the air forces. Part of Secretary Finletter's response was that the Air Force must stay on the forefront of technology.[12] With a separate Air Force at last achieved, the new Air Force leadership set about to insure that the Air Force could stay on the forefront of technology.

General Arnold's previous attempt to establish a workable DCS/R&D organization had failed for many reasons, including those mentioned above. One other considerable stumbling block was the Air Materiel Command (AMC). AMC was seen as too parochial to stockpiles. AMC wanted to focus on cost, quantity, and maintainability.[13] Technological breakthrough was not a significant goal. The DCS/Materiel, Directorate for R&D, Major General Donald L. Putt, authored a study showing that the Air Force trailed behind the other Services in R&D budget, personnel, and facilities. General Putt

advocated a separate command for R&D if the Air Force was to develop the technology required for the future Air Force.[14] General Putt's position had almost no support on the Air Staff, as other DCS organizations saw a new command as a financial and personnel drain on the existing commands. But General Putt had support where it mattered, from the Chief of Staff, and thus a new command was slated to stand up at Wright-Patterson Air Force Base on December 1, 1950.[15]

The new command, Air Research and Development Command (ARDC), shared Wright-Patterson AFB with AMC, but that is all that they shared. There was still friction between the two commands. Specifics of the disagreements revolve mostly around mature development and production issues that are beyond the focus of this study. However, one significant result worthy of mention is that many of the responsibilities defined at this time would hold until the Air Force Systems Command and Air Force Logistics Command merged into Air Force Materiel Command in the early 1990s.

Summary

An analysis of Air Force RDT&E in this period is difficult. Many dramatic changes were occurring, not the least of which was the establishment of the Air Force as a separate Service. A proposed rating might be as follows:

Innovation……**X**……………………………………………..Efficiency
Revolution…………………………**X**……………………..Improvement
Capability………**X**……………………………………………Threat
Independence…………………**X**……………………..…..….Reliance
Vision……………………….**X**………………………………Requirements

With a strong, visionary leader in General Hap Arnold and a bold new direction posed by *Toward New Horizons*, the Air Force appeared posed to leap ahead into new technology areas. In supersonic flight technologies, this may have been the case. But the

progress was not what had been hoped in terms of the vision of *Toward New Horizons*. Air Force R&D manning and budgets were not what had been hoped for in the wake of the rapid post war demobilization and competition from other requirements. The R&D organization was beginning to solidify, but was still at odds with AMC and viewed warily by other commands an economic and personnel drain. Perhaps the situation was best summed up by the 1950 SAB study known as the Ridenour Report:[16]

> The basic reasons for failure to carry out such good intentions concerning research and development are entirely understandable. The Air Force has been preoccupied ever since the war with a series of major, immediate problems which left no effort available for investment in research and development activities.

Despite the growth of the Soviet bloc in Eastern Europe and the Berlin Airlift in 1948-49, there were no asymmetric threats for the U.S. Air Force to deal with. Indeed, there seemed to be no threats at all in the late 1940s. This would soon change, as once again the U.S would be shocked into action by the Cold War.

Notes

[1] Henry H. Arnold, Memorandum to Dr. Von Karman, Subject: AAF Long Range Development Program, 7 November 1944.

[2] Von Karman, *Where We Stand,* 1.

[3] Von Karman, *Where We Stand,* 6.

[4] Ibid., iv.

[5] Theodore Von Karman, *Science, The Key to Air Supremacy: Report to the General of the Army, H. H. Arnold, Submitted on Behalf of the A. A. F. Scientific Advisory Group,* December 1945, ix-6. The conclusions presented in this report are:

1. The discovery of atomic means of destruction makes a powerful Air Force even more imperative than before.
2. The scientific discoveries in aerodynamics, propulsion, electronics, and nuclear physics opened new horizons for the use of air power.
3. The next ten years should be a period of systematic, vigorous development, devoted to the realization of the potentialities of scientific progress, with the following principal goals: supersonic flight, pilotless aircraft, all-weather flying,

perfected navigation and communication, remote-controlled and automatic fighter and bomber forces, and aerial transportation of entire armies.

4. Research problems should be considered in their relation to the functions of the Air Forces, rather than as isolated scientific problems.
5. Development centers should be established for new types of equipment and for making practical new methods suggested by scientific discoveries. Such development centers were more efficient than separate laboratories for various branches of science.
6. The use of scientific means and equipment required the infiltration of scientific thought and knowledge throughout the Air Force and, therefore, demanded certain organizational changes in recruiting.
7. A global strategy for the application of novel equipment and methods, especially pilotless aircraft, needed to be studied and worked out. The full application of air power required a properly distributed network of bases within and beyond the limits of the continental United States.
8. As new equipment became available, experimental pilotless aircraft units would be formed and personnel systematically trained for operation of the new devices.
9. According to the outcome of a practical testing period, a proper balance between weapons directed by humans, those assisted by electronic devices, and purely automatic weapons would be established.
10. The men in charge of the future Air Forces must remember that problems never have final or universal solutions, and only a constant inquisitive attitude toward science and a ceaseless and swift adaptation to new developments would maintain the security of the U.S. through world air supremacy.

[6] Ibid.

[7] Ibid., xiii.

[8] Baucom, *Air Force Images of Research and Development and Their Reflections in Organizational Structure and Management Policy*, 44-47.

[9] Ibid., 71-74.

[10] Ibid., 77.

[11] Ibid., 78.

[12] Gorn, 6.

[13] Ibid., 7, 26.

[14] Ibid., 10.

[15] Ibid., 18.

[16] United States Department of the Air Force, Scientific Advisory Board, *Research and Development in the United States Air Force*, 21 September 1950, iv-1.

Chapter 4

Cold War R&D

The post World War II period was a time of tremendous change with the formation of a new Air Force, a new Office of the Secretary of Defense, and the massive demobilization of men and war materials. For the Air Force, the long awaited recognition as a separate Service had brought new opportunities and challenges. Budgets had dropped dramatically under the fiscally conservative President Truman. Escalating tensions with the Soviet Union culminated in the Berlin Airlift in 1948-49. The Berlin Airlift was a victory for the U.S. and the Air Force. But it was a different kind of battle and a different kind of victory than the Air Force was accustomed to in World War II. The Cold War would be fought in an entirely different way than any other war.

Strategic Context at the Beginning of the Cold War

As already discussed, the late 1940s were a period of tremendous demobilization and significant budget reductions. The U.S. had no world peer to worry about. The U.S. was the only nation with the ultimate weapon, the atomic bomb, and best estimates reasoned it would be 1952 before any other nation was capable of producing A-bombs.[1]

The Department of Defense budgets under President Truman were difficult for all the Services. Defense budget requirements of $30 billion were given a presidential

budget level of $19 billion. President Truman was adamant about reducing what he perceived as the waste in the Department of Defense, and lean budgets were just the way to do it.

The austere budgets were one of the reasons for significant Service infighting in the post war era. Another related battle was over the development and responsibility for new weapons. All the Services wanted greater roles and missions responsibility. This was especially apparent in the new guided missile development arena. As a result, all of the Services were given some part of the guided missile development and fielding requirement. This splitting of responsibilities may not produce the optimal effort, but also resulted competition among the Services and new ideas for meeting mission requirements.[2] For example, if the Air Force had had sole responsibility for nuclear weapons development, would the submarine-launched ballistic missile have been developed? The potential of strategic bombing and ICBM advocates supporting such a concept is doubtful.[3]

Unfortunately for the U.S., the end of the 1940s and beginning of the 1950s brought rapid changes. In August 1949, the Russians successfully detonated an atomic bomb. In 1950, the U.S. became involved in the Korean War. The early 1950s brought intelligence estimates of the Soviet Union working on long-range ballistic missiles capable of delivering atomic weapons, particularly the new hydrogen bombs that both the U.S. and Soviet Union had developed. By the late 1950s, the U.S. was conducting a crash program to develop long range ballistic missiles to close the perceived gap with the Soviet Union.[4] How had the U.S. fallen so far behind in only ten years?

Air Force RDT&E, Late 1940s to Late 1950s

The late 1940s were difficult times for the Air Force RDT&E establishment. ARDC had not yet been formed, so development fell under the more logistically oriented AMC. Manning had been cut in the free fall of demobilization. Inter-Service dog fights over roles and missions resulted in difficult coordination issues. But the most egregious failure was the funding situation.

RDT&E funding was severely cut in the late 1940s. In fairness to the Services, there were few alternatives in the austere times of the Truman administration. Mr. Vannevar Bush, Chairman of the Research and Development Board, recommended limiting all military research and development for fiscal year 1949 to $500 million.[5] With overall Department of Defense (DoD) and Air Force funding down, the cuts rippled down to future program developments. Guided missile funding was cut to the bone. In 1948, missile production funding was $13 million and missile R&D was $20 million. In 1949, the figures had fallen to $10.3 million for production and only $7 million for R&D. This resulted in part from a Truman policy that precluded the Services from funding any program requiring larger investments in the subsequent years.[6] The emphasis was clearly on the here and now; making do with what was available. As a result, the Air Force truncated or terminated ten of 28 guided missile R&D efforts and concentrated on near term tactical missile R&D efforts.[7]

The concentration of limited R&D funding on near term tactical missiles reflected Air Force strategic thinking at the time. In addition to believing no other nation would be able to develop the atomic bomb until 1952, Air Force leaders in 1948 believed the subsonic bomber would be the only deliver method for at least ten years. In terms of the

atomic bomb, this is probably good reasoning for the time, as the atomic bombs were large, heavy payloads. Thus air-to-air and air-to-ground missiles, which would allow the bombers to penetrate enemy airspace to deliver their atomic payloads, took precedence. The long range intercontinental ballistic had a long development time, required large investments, and needed new development and test facility investments in addition to the large payload requirement mentioned previously. All of these factors placed the intercontinental missile at the low end of the priority system for scarce R&D funding.[8]

On November 1, 1952, the U.S. exploded its first hydrogen bomb. Air Force leaders who knew of the event were excited about the possibilities it presented. The hydrogen bomb packed a much larger punch in a smaller package than the atomic bomb. Despite senior leadership excitement, the official Air Force position was that long range ballistic missiles were not a revolutionary weapon. Lieutenant General Earle E. Partridge, commander of ARDC, scoffed at the idea long-range missiles were not revolutionary. He argued any weapon that could deliver a hydrogen bomb 5,000 miles was certainly revolutionary. He further reasoned that the Air Force needed to change its thinking and consider the possibilities offered by long-range missiles. The Air Force, however, was worried an internal debate over the role of long range missiles would weaken the Air Force overall position against the other Services, and thus avoided refuting the party line.[9]

By the mid-1950s the Soviet Union also had the hydrogen bomb. There were also estimates that the Soviets were working on a long-range missile for delivery of the hydrogen bomb. A report to the President in February 1955 noted a growing weapons disparity between the U.S. and the Soviet Union.[10] In response, the Air Force sought top

DoD priority to speed up the development of the intercontinental ballistic missile (ICBM). This top priority objective was achieved, but organizational problems once again provided a stumbling block to expediting development.

While ARDC had been established as a separate command from AMC in 1950, nearly 80 percent of the R&D funding was controlled by AMC. This control gave AMC considerable say in how programs were conducted. ARDC wanted to proceed on a risky but faster concurrent engineering approach, which would allow several development efforts to proceed simultaneously. AMC wanted to continue on a low risk serial development path, which would proceed with the next phase of development only after the previous phase had been proven successful. The issue was finally resolved in ARDC's favor, but the problem showed a serious defect in conducting research and development. General Bernard Schriever would later provide the answer for resolving the issue by proposing an arrangement that would become Air Force Systems Command (AFSC) and Air Force Logistics Command (AFLC).

The requirement imperative for ICBMs also sped infrastructure investments. Recognizing the need for an ICBM test range, the Air Force negotiated the transfer of Camp Cook at Lompoc, California from the Army in 1956. This would later become Vandenburg AFB and the home of the ICBM test programs. The Air Force invested heavily in establishing the test assets at Vandenburg AFB. Initial construction began in April 1957, and over a 26 month period $750 million had been spent.[11] The investments at Vandenburg exemplify the types of investments that the Air Force was willing to make by the late 1950s.

Summary

As with the immediate post-World War II period, the early years of the Cold War are difficult to evaluate. The post war era brought tremendous budget and manning frustrations that affected Air Force decisions on technology development. Rivalries with the other Services also placed the Air Force in a difficult position concerning internal debates over investment priorities and placed the ICBM development effort behind the Soviets. With these factors in mind:

Innovation……**X**……………………………………………..Efficiency
Revolution……………**X<---------------------------X***……..Improvement
Capability……………………………**X------------→X***..……Threat
Independence……………**X**………………………..…..….Reliance
Vision……………………………………**X**……………….Requirements

* The shift to left reflects the change to develop a revolutionary capability – the ICBM – in response to the shift to the right in the threat – the perceived Soviet lead in ICBM development.

In some respects, the Air Force had clung to the bomber mindset instead of reaching for the potential of ICBMs for rational reasons. The original atomic bombs were too cumbersome for the long-range missiles that were envisioned at the time. The severely restricted budgets, plus the need for significant investments in facilities to test ICBMs, made the ICBM development effort appear to be unaffordable in light of other needs.

This once again strikes at the heart of the issue. Senior Air Force leaders had seen the tremendous possibilities of ICBMs coupled with the development of the hydrogen bomb. However, the official Air Staff position did see the revolutionary potential of the ICBM. General Bernard Schriever's approach of putting together a expert team of government and contractors, plus pursuing a concurrent engineering approach for development, was certainly the key contribution to the fielding of Air Force ICBMs.

The saga of early ICBM development illustrates the pressure of today's requirements versus tomorrow's promise. Faced with the choice of a potentially risky and long-term investment over improving today's systems performance, the Air Force chose today's system. Certainly, the priorities of the Truman administration also added to this near-term mindset. Inter-Service rivalries were very much a contributing factor as well. One result of inter-Service rivalry issues was the perception that the Office of the Secretary of Defense (OSD) should have a stronger leadership posture. Changes to make this happen would occur during a time growth in the RDT&E structure in the 1960s.

Notes

[1] Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960*, (Washington D.C.: U.S. Government Printing Office, 1989), 56.
[2] Ibid., 36.
[3] James R. Schlesinger, *Defense Planning and Budgeting: The Issue of Centralized Control* (Washington, DC: Industrial College of the Armed Forces, 1968), 18.
[4] Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960*, 51-57.
[5] Ibid., 67.
[6] Ibid., 56-57.
[7] Ibid., 26.
[8] Ibid., 27.
[9] Ibid., 89-91.
[10] Ibid., 94, 120.
[11] Gorn, *Vulcan's Forge*, 44.

Chapter 5

Growth and Change: 1960s Through 1980s

The 1960s would become a period of growth and change for the Air Force RDT&E infrastructure. Manpower and funding, as shown in Appendices A and B, would increase. Space research would flourish. Air Force organizational structure would stabilize the development process, while new OSD policies and power would have an effect on the process also.

Strategic Context

The space program served as a catalyst for the Air Force in several ways. First, the battle between ARDC and AMC would be resolved. The space mission had been promised to the Air Force if it could straighten out its R&D organization. General Schriever's proposal to centralize research, development, and production responsibilities in one command and logistics responsibilities in another was accepted. This resulted in Air Force Systems Command (AFSC) and Air Force Logistics Command (AFLC) in 1960. AFSC now had the responsibility, authority, manning, and funding sought by the R&D advocates over a decade earlier.[1]

Second, the new AFSC would be thrust headlong into the space race as the DoD lead agency. The new AFSC commander, General Schriever, commissioned a Space Study

Committee to provide a status review. The committee estimated that the Soviet Union had a three to five year lead in space system development, and recommended a program similar to the ICBM effort to close the gap. Having been surprised by the Sputnik launch in 1957, the U.S. was once again surprised by the first manned orbiter launched by the Soviets in April 1961.[2] The Air Force would begin investing heavily in the technology and infrastructure to close the space gap. While the Air Force had achieved what many believed was an optimal solution for the creation of a command for research, development and procurement, events in OSD would change the functioning of the command.

New Organizational Realities

The DoD reorganization act of 1958 laid the groundwork for sweeping changes in the relationship between OSD and the Services. More responsibilities were given to the Secretary of Defense at the expense of the Services. When Defense Secretary McNamara came to power in the Kennedy administration, he reformed the defense establishment and centralize control.[3]

Secretary McNamara's key initiative was the Planning, Programming and Budgeting System, or the PPBS. The purpose, as the name implies, was to produce a plan, program and budget for the Department of Defense. The PPBS introduced several new concepts for the DoD including resource programming, cost-effectiveness analysis, multi-year budgeting, and centralization of the resource allocation process.[4] Resource programming would be the most important of these concepts.

Resource programming was intended to bridge the gap between military planning and budgeting. Resource programming would use analytical techniques and output-oriented budget categories to match plans and desired capabilities with dollars. This action was aimed at the almost complete separation between planning and decision-making on weapons systems and the budgeting process. Until 1961, defense budgets had been stated in terms such as military pay, construction, and procurement – basically input oriented definitions. The PPBS intended to recast the budget in terms of output-oriented programs – strategic defense, general purpose forces, and R&D. These would become known as major force programs, and program number six of these would become the RDT&E major force program. In addition, the budget would become multi-year program versus the single year submission as it had been up until 1961. First known as the Five Year Defense Plan (FYDP), it has evolved to now be a six year budget, known by the same acronym with "Future" replacing "Five".[5]

The reform of the budget process and the centralization initiatives under Secretary McNamara were significant emotional events for the Services. Much of the decision making power was now centralized in OSD. As with all the other major force programs, RDT&E had to be justified in terms of outputs to the other major force programs. Furthermore, OSD now had insight into all the Services RDT&E efforts and could examine them for perceived or real duplication. Also, the emphasis on cost analysis and cost benefit arguably provided an advantage to near-term low-risk programs in contrast with research that may not pay off for many years or have an identified weapon system application.

Many changes have occurred in the PPBS over the past thirty years, but two are particularly relevant to RDT&E. The first series of changes were made in 1969 and 1970 by Secretary Laird, and essentially put more control back in the hands of the services by replacing specific program guidance with broader fiscal guidance. The second change was implemented though the Goldwater-Nichols Act, and provided a mechanism for the Unified and Specified Commands to provide inputs to the process.[6]

The PPBS placed more emphasis on requirement and spending match-ups. The subsequent addition of the Unified and Specified Command inputs further strengthened the potential that near-term requirements would take precedence over long-term technological breakthroughs. Indeed, the entire process has become more business oriented and tended to stifle highly innovative programs, particularly in a large bureaucratic system such as the DoD.

Growth of AFSC

OSD had introduced new controls on the RDT&E process, and AFSC was at least postured to cope with the new battles inside the Washington DC beltway. The 1960s through the 1980s saw the growth of AFSC in terms of manning, funding and facilities.

AFSC manning levels began growing significantly in the early 1960s. Despite a downturns in USAF manning in the early 1960s, R&D manning grew by 42 percent. R&D manning grew proportionally with overall Air Force manning during the Vietnam War. The post war downturn resulted in over 20,000 fewer Air Force officers by 1975, but R&D officer manning stayed relatively constant, resulting in approximately 9 percent of all officers having an R&D specialty.[7] Civilian manning peaked in 1965 at

approximately 36,000. The civilian manning declined to 29,500 by 1970, and fluctuated between 26,000 to 30,000 through the 1970s to the early 1980s.[8]

Funding would also increase in the early 1960s. The RDT&E funding level would increase from $814 million in 1959 to $3 billion by 1965. Even with a slight decrease after Vietnam, the RDT&E funding level for the Air Force would stay roughly between $3-4 billion until the beginning of the 1980s. The 1980s would bring the Reagan defense buildup, and RDT&E funding would jump to $14.4 billion by 1985.[9] Much of the 1960s funding would go towards supporting the space program. Investments in facilities would also strongly lean toward space chambers and rocket test capabilities.

Facilities in the 1960s grew to support the nation's space program. Arnold Engineering Development Center (AEDC) in Tullahoma Tennessee, for example, added several multi-million dollar space chambers and rocket test cells to support both the space program and the still robust ICBM program.[10] Growth in facilities would also be fueled by the Reagan defense build-up through the 1980s. Again using AEDC as an example, the Aeropropulsion System Test Facility (ASTF) was built at a cost of $650 million. The finest turbojet engine test facility in the world, it held the distinction of being the single most expensive Air Force military construction program at that time. In addition, ASTF was built with a vision for the future of engine technology. The facility had been built with extra capacity long before huge turbofan engines or thrust vectoring nozzles had been built. Yet the ASTF complex could accommodate these new engines in the 1990s, and was a key asset in evaluating large turbofans and the engines competing for the F-22 fighter.[11]

Summary

The proposed rating of this period is as follows:

Innovation……**X**…………………………………………..Efficiency
Revolution………………………**X**……………………..Improvement
Capability……………………………………………**X**………Threat
Independence…………………**X**…………………..…..….Reliance
Vision…………………………………**X**………………Requirements

The Air Force continued to invest in innovative technologies to counter the growing threat of the Soviet Union and Warsaw Pact. This period appears to strike a balance between research in revolutionary technologies such as stealth, and improvements in current technologies such as the development of the F-15 and F-16 fighters. There were some new realities that would change the relationship of technology development to fielding of systems.

While organization, funding, and facilities had all improved during the 1960s to late 1980s timeframe, there were some issues of note. The McNamara reforms had some problems. The Air Force found itself less in control of system development. A number of high profile and costly system problems, such as the C-5 and F-111 programs, were partially the cause of reforms in the 1969-70 timeframe to encourage prototyping and put some of the control back in the hands of the services.[12] While fundamentally a development and acquisition issue, the reforms also served to lengthen the time between technology identification, maturation, and fielding in systems.

The Air Force Systems Command enjoyed a robust growth during the 1960s-80s, with the greatest growth in the space arena. In addition to working hand in hand with the National Air and Space Administration (NASA – successor to the NACA), the Air Force also worked satellite programs for Air Force and DoD purposes.[13] This focus was would

have costs in other areas, particularly in tactical systems. This would be evident by the end of the Vietnam War, as needed improvements in tactical aviation would be identified. This would lead to the F-15 and F-16 development programs in the 1970s. Strategic forces would also be seen as lacking, leading to the development of the Peacekeeper missile and the B-1B bomber.[14]

The increases in personnel, funding, and infrastructure during the 1960s-1980s placed AFSC at the forefront of Air Force major commands, and at the forefront of technology. The focus had been on providing the best weapons systems, with the best technology, and at an affordable cost. This strategy had been a cornerstone of the Cold War and was a contributor to the eventual "victory" in the Cold War. The end of the Cold War would bring new realities to be considered and new paradigms to be developed concerning the Air Force's role in research and development.

Notes

[1] Gorn, *Vulcan's Forge*, 70.
[2] Ibid., 70, 77.
[3] Daniel J. Kaufman in *Defense Technology*, edited by Asa A. Clark IV and John F. Lilley, (New York: Praeger Publishers, 1989), 183.
[4] Michael D. Burnes, *The History, Concepts and Phases of the PPBS*, (Washington, DC: Air Force Studies and Analysis Agency, 25 August 1992), 1.
[5] Ibid., 1-2.
[6] Ibid., 4.
[7] Michael H. Gorn, *Harnessing the Genie, S&T Forecasting for the Air Force, 1944-1986*, (Washington DC: Office of Air Force History, 1988), 88.
[8] Gorn, *Vulcan's Forge*, Appendix 4-1.
[9] Ibid., Apppendix 4-3.
[10] AEDC info
[11] AEDC info
[12] Gorn, *Vulcan's Forge*, 86-87.
[13] Ibid., 77.
[14] Ibid., 77, 125-126.

Chapter 6

New Realities: The 1990s

The Cold War ended in a great, but unusual, victory for western democracy. Unusual in that the grand battle of pervious wars was missing. The Cold War had been a battle of ideologies and economies, as wel as a battle of technological breakthroughs and counter-breakthroughs; of military competency and political resolve. The end of the Cold War left a one-superpower world in its wake – a superpower anxious to turn resources to other priorities than the military. The military would have to cope with declining budgets, new challenges, and new paradigms for the future.

Strategic Context

The culmination of the Cold War could perhaps be viewed in the context of the Gulf War. The overwhelming superiority of technology such as stealth, airborne and satellite surveillance and information capabilities, and precision weaponry vindicated the investments of the 1980s. Technology was a significant force multiplier. Yet, these were essentially Cold War weapon development efforts. The Air Force and the DoD could not count on the largess of the American people to continue the military establishment at Cold War levels. Indeed, the declines in force structure began even before the Gulf War, and are well documented. Overall, the force structure has declined 34 percent from 1990 levels. The declines in personnel end strengths and units were coupled with several

rounds of base closings to reduce infrastructure. New examinations of the RDT&E infrastructure would bring new recommendations in manning, funding, and infrastructure.

Outside Examinations and Recommendations

The early 1990s would bring new proposals for the shape of the DoD RDT&E infrastructure. Three studies by the Office of Technology Assessment (OTA) in 1989, 1992, and 1993 provided recommendations for Congress concerning the R&D and the defense technology base. In the 1989 report, *Holding the Edge: Maintaining the Defense Technology Base*, the OTA offered a review of the national technology base at the request of the Senate Committee on Armed Services. This survey found that DoD support for research and exploratory development programs had decreased over the past twenty years, both in terms of the DoD budget and the RDT&E budget. In the mid-1960s, research and exploratory development represented 25 percent of the budget. By 1989 it was less than nine percent. One reason for this decline, in light of the growing RDT&E budgets during this period, was the increased use of advanced technology demonstrators and the Space Defense Initiative in the 1984-90 timeframe.[1] This OTA report also recommended a stronger role by OSD, specifically the Director, Defense Research and Engineering (DDR&E), in developing and implementing a strategic plan for DoD technology efforts. In addition, it recommended greater civilian/military interface in technology efforts. Finally, the report recommended either reforming civilian personnel practices to allow greater hiring flexibility or examining conversion to "GOCOs" (Government Owned, Contractor Operated) of some laboratories.[2]

The 1992 OTA study echoed the previous study in many respects. Regarding budget, the report cites the RDT&E portion of the defense budget being consistently 10-

11 percent of the overall budget for the past 30 years. The report stated that RDT&E budgets could reasonably be expected to stay at 10-11 percent, and therefore decline in proportion to the defense budget.[3] The study further proposed an integrated national technology base, stating that the question was not whether the national technology base would shrink, but how best to manage a reduced infrastructure.[4]

The final OTA report, published in 1993, noted the recent stabilization of the RDT&E budgets, based on the new DoD strategy to maintain technological superiority. While defense budgets had declined 20 percent since the 1989 timeframe, RDT&E dropped only 12 percent. The largest share of the budget cuts had been absorbed by the procurement accounts, which had dropped 30 percent in the same timeframe.[5] Thus, the trend feared in the 1992 report had been somewhat checked, although the consequences would come later as will be discussed later concerning the Quadrennial Defense Review (QDR) of 1997. The 1993 report advocated technology transfer and dual use technology efforts as a way to support the federal laboratory system.[6]

In general, these reports viewed the declining RDT&E budgets and infrastructure with concern, and recommended various paths to preserve or protect the infrastructure. The report recommendations were predicated on DoD developing a strategic plan that would help guide decisions concerning infrastructure and research requirement. OSD had begun the process to develop such a plan at the beginning of the 1990s.

By 1989, senior DoD officials had become concerned about the viability of Science and Technology (S&T) development in Defense Technology Base programs. In October 1989, the Deputy Secretary of Defense issued a draft of Defense Management Report Decision 922 challenging the Services to create a new approach to S&T that would

increase efficiency and eliminate unwarranted overlap in the RDT&E activities of the respective Services. The Services responded to the report with numerous studies, one of which was called Project Reliance.[7]

Project Reliance was initially an Army and Air Force proposal to examine opportunities to consolidate and collocate their R&D efforts at single locations for selected technology areas. Project Reliance was expanded to include the Navy and added T&E to the process in 1990. Project Reliance thus has become one of the most comprehensive RDT&E restructuring efforts of the past 40 years.[8]

The Reliance process took on a new dimension in 1995, as the Director of Defense Research and Engineering assumed responsibility for Reliance management and formed a new strategic planning process for the entire S&T program. The planning process generates several documents, including the Defense S&T Plan, the Basic Research Plan, the Joint Warfighting S&T Plan, and the Technology Area Plan which present the DoD S&T vision, strategy, plan and objectives. The T&E community underwent similar revisions, with "leads" being assigned for various T&E functions.[9]

Against the backdrop of increased OSD oversight and studies recommending greater outsourcing and efficiencies, the Base Realignment and Closure (BRAC) process imposed fundamental, irreversible changes on the RDT&E infrastructure. This study will only touch on the highlights of the BRAC process for the Army and the Navy.[1]

Each of the Services has closed or consolidated numerous RDT&E facilities. The Army consolidated facilities and moved toxicology research to the Air Force. The Army projects a 29 percent reduction in RDT&E personnel from Fiscal Year (FY) 1996 to FY

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[1] For a complete review of the RDT&E background information, the reader is refered to: http://www.dtic.mil/labman/vision21.

2001. The Navy also consolidated internally for the most part by pursuing a strategy of combining RDT&E infrastructure and system acquisition whenever possible. Thirteen RDT&E sites are being closed and 27 RDT&E tenant sites are also closing. The Navy has cross-serviced some RDT&E functions, most notably the RDT&E mission for jet engines from Trenton New Jersey to AEDC.[10]

Change in Air Force RDT&E Structure

The robust growth in RDT&E during the 1980s had resulted in an Air Force structure with 14 separate laboratories by 1990. These would be organizationally consolidated into four laboratories in 1991 to both reduce management overhead and improve support to the four Product Centers. Some non-core technical areas were eliminated. These areas include the transfer of nuclear technology to the Army and tactical missile propulsion to the Navy. A number of technology areas have been reduced in scope, including advanced communications, tactical surveillance, and short takeoff/landing. In addition, a number of operating locations and facilities have been closed or mothballed. Facilities mothballed include over 70,000 square feet of research facilities at Wright Patterson AFB – including four wind tunnels and an aircraft structural test facility.[11]

Personnel reductions in the Air Force laboratory structure have been dramatic. From an FY 1989 manning level of 8,493, the total laboratory manning dropped to 6,392 in FY 1996 – a 25 percent reduction. FY 2001 projections will further reduce laboratory manning to 5,129 – over a 39 percent decrease from 1989.[12]

Air Force T&E facilities underwent a similar process to the S&T laboratories. Numerous small test ranges and sites were closed or consolidated into facilities. The

1993 BRAC process moved the 4950th Test Wing from Wright-Patterson AFB to Edwards AFB. The 1995 BRAC process realigned and consolidated electronic combat testing, and transferred the Utah Test and Training Range to Air Combat Command to support training. When the 1995 BRAC process is complete, the Air Force will be left with three major test bases at Edwards AFB, Eglin AFB, and Arnold AFB (AEDC), and one test site at Holloman AFB to support munitions testing, guidance and control, and radar cross-section test and evaluation. Test aircraft have also declined significantly, down 50 percent by 1995 from the 1987 peak year.[13]

In terms of personnel, by 1996 Air Force T&E manning had declined to 8,033 from 9,226 in FY 1989 (13 percent). Projections show reductions of 34 percent by FY 2001 from FY 1989 levels. Declines in funding are also dramatic, as direct funding for T&E Centers decreased 34 percent by FY 1996 from the FY 1989 level of $521 million.[14]

At a higher level, the RDT&E infrastructure was affected by another event in the early 1990s. As a part of the Air Force process of Integrated Weapon System Management (IWSM), AFSC and AFLC were once again merged into one command – Air Force Materiel Command (AFMC). This merger allowed combination and reduction of command staffs and fostered the "single manager" philosophy for weapon system management as a seamless process throughout the life of a system. As part of the IWSM and Single Manager processes, all necessary product functions – program management, requirement definition, systems engineering, contracting, technology, logistics, and test and evaluation – are integrated as part of an Integrated Product Development concept.

Summary

Based on the situations developing in the early 1990s, the trends are:

Innovation……………………………………**X**……………..Efficiency
Revolution…………………………………………**X**……..Improvement
Capability…………………………………………**X**………Threat
Independence…………………………**X**……………..…..….Reliance
Vision…………………………………………**X**…………Requirements

By 1995, Air Force RDT&E had come almost full circle to a combination of the early 1950s and early 1960s. Dramatic budget reductions, personnel drawdowns, and base/facility closures were not unlike the Truman years. Studies pressing for new business practices, partnership with NASA or industry, and centralization of control in OSD are reminiscent of the McNamara era. Finally, new consolidation of planning and funding under OSD also bring memories of the McNamara initiatives to consolidate control in OSD. The impact of these changes is difficult to ascertain precisely, but some conclusions can be drawn.

First, there is no question that the technology base in the United States has eroded. All the Services have admitted to giving up or giving away "non-core" technology efforts. Some, probably most, technology efforts have been slowed down. Not all of this is bad, and no doubt some efficiencies have been gained. However, the broad front of technological endeavors enjoyed in the 1980s has certainly narrowed. The impact is not just in the DoD system. The Air Force, for instance, has traditionally outsourced more R&D than the other Services. The Air Force has typically outsourced 65 to 80 percent of its research efforts to firms and universities.[15] The impact is being felt throughout the national R&D establishment.

In terms of T&E, some of the consolidations have helped focus T&E efforts at the three major centers. The transfer of jet engine workload from the Navy Trenton New Jersey facility to AEDC has increased workload, added several new engine test facilities, and added 14 Navy personnel to AEDC. The disadvantage is that no additional operations and maintenance funds were provided for supporting the new facilities.[16] Funding for new capabilities and upkeep of old facilities has been woefully lacking in the 1990s. Potential for major test facility problems impacting major acquisition programs is real and growing. Furthermore, new test facilities to support new technologies, such as Mach 10+ hypersonic air-breathing vehicles, are not being funded.[17]

The attempts to centralize management in OSD for RDT&E have been a mixed blessing. To some degree, another management layer has been added to the process given that the Services still have their own prioritization requirements and processes. Furthermore, significant redirection of DoD technology efforts has not been the norm. Rather, a "peanut butter" spread approach to funding and funding reductions appears to be the status quo. Furthermore, the addition of new processes has lengthen the time for projects to be approved in both the S&T and T&E process, as numerous tri-Service and OSD checkpoints now exist.[18]

Notes

[1] U.S. Congress, Office of Technology Assessment, *Holding the Edge: Maintaining the Defense Technology Base*, OTA-ISC-420 (Washington, DC: US Government Printing Office, April 1989), 56.

[2] Ibid., 12-15.

[3] U.S. Congress, Office of Technology Assessment, *Building Future Security*, OTA-ISC-530, (Washington, DC: U.S. Government Printing Office, June 1992), 35.

[4] Ibid., 19-22.

Notes

[5] U.S. Congress, Office of Technology Assessment, *Defense Conversion: Redirecting R&D*, OTA-ITE-552 (Washington, DC: U.S. Government Printing Office, May 1993), 148.

[6] Ibid., 1-7.

[7] Department of Defense, *Vision 21: The Plan for 21st Century Laboratories and Test and Evaluation Centers of the Department of Defense*, n.p. On-line. Internet. Available from: http://www.dtic.mil/labman/vision21/.

[8] Ibid.

[9] Ibid.

[10] Ibid.

[11] Ibid.

[12] Ibid.

[13] Ibid.

[14] AFMC/DO unpublished information. November 1996.

[15] U.S. Congress, Office of Technology Assessment, *Defense Conversion, Redirecting R&D*,

[16] Author's personal knowledge, having been intimately involved in the planning and execution of the transfer of Navy capability while assigned to AEDC.

[17] Author's knowledge as Deputy, Long Range Plans at AEDC in 1994-95, and as Chief of T&E Investments on the Air Staff, 1995-97.

[18] Author's experience working the tri-Service T&E Reliance process. A lengthy study of the process by the T&E Joint Program Office in which the author participated found the number of steps and length of time for program approval to be the number one issue.

Chapter 7

New Vision, New Challenges

The rapidly declining defense budgets and the significant changes in organizational structure – the creation of Air Force Materiel Command (AFMC) – would be coupled with new examinations of future RDT&E requirements. Approaching the fiftieth anniversary of *Toward New Horizons*, the Secretary of the Air Force and the Air Force Chief of Staff would commission the SAB to do conduct a study of the technologies that would ensure air and space superiority into the twenty-first century. The study, titled *New World Vistas*, which provided a perspective for the twenty-first century in a similar pattern to *Toward New Horizons*, would be the first of several planning documents important to the future of RDT&E.

New World Vistas

The Secretary of the Air Force and the Chief of Staff of the Air Force chartered *New World Vistas* to be a ten-year technological forecast.[1] In response to this tasking, the SAB produced 15 unclassified volumes and one classified volume, plus an ancillary volume. The *New World Vistas* report, delivered in December 1995, provided recommendations for the future in a host of technology areas important to the Air Force, as well as proposals and observations concerning funding, personnel, and organization of

S&T. A complete review of *New World Vistas* is not the subject of this effort, but a few important concepts will be addressed to provide appropriate background.

A number of recommendations were made by the SAB for technologies the Air Force should pursue within six capability areas[2]. Of the 28 recommendations in these capability areas, a number of them were deemed to be "revolutionary" technology areas[3].

The SAB also made recommendations on technologies the Air Force should buy versus develop, such as software tools and languages. In addition, the SAB recommended services and equipment to buy without development, such as high-speed processors, focal plane arrays, and space launch.[4]

In accordance with the direction from the Secretary of the Air Force and the Chief of Staff, the SAB also offered recommendations for things the Air Force should not do or stop doing[5].

The SAB also recommended areas in which the Air Force should utilize commercial and university research and development efforts rather than make investments in the developments. These include high capacity communications "backbones" and multimedia technologies. Furthermore, the SAB recommended an independent, outside panel be established to review priorities of S&T programs, provide an impartial viewpoint of the value associated with the S&T efforts, and eliminate low priority efforts. Finally, the SAB recommended the Air Force invest 15 percent of its S&T resources over the next five years in S&T areas directly related to *New World Vistas* proposals for new and innovative programs.[6]

The SAB also addressed personnel and organizational issues. While recognizing that personnel reductions in S&T were likely, the SAB recommended increasing the number

of technical advanced degree opportunities. The SAB also recommended opportunities for practical experience in industry and National Laboratories be expanded.[7] Organizationally, the SAB recommended a reorganization to bring the labs under an Air Force Technology Executive Officer (AFTEO), versus being assigned to various Air Force Product Centers.[8]

The technological progress of 50 years is illustrated by comparing *New World Vistas* to *Toward New Horizons*. The explosion in computer and information technologies have both supplemented traditional aerospace development efforts and become military applications in and of themselves. The maturation of space systems and launch vehicles is evident in the SAB recommendation to rely on commercial capabilities. Some areas, such as unmanned vehicles, are just now becoming operational systems that will require more technology development. *New World Vistas* shares another potential common bond with *Toward New Horizons* as both were developed in a climate of budget reductions and manning reductions. Another important study, known as Vision 21, would focus on the Service's RDT&E community.

Vision 21: Reduce, Restructure, and Revitalize

The Vision 21 process responds primarily to sections 277 and 265 of the National Defense Authorization Act for Fiscal Year 1996. Section 277 calls on the Secretary of Defense to develop a five-year plan to consolidate and restructure the laboratories and T&E centers of the DoD by October 1, 2005. Section 265 requires the Secretary of Defense to conduct a comprehensive review of the aeronautical research and test facilities to access their current condition.[9]

In response to Section 277 and Section 265, OSD teamed with the Services to develop a plan known as Vision 21. Vision 21 will be developed based upon the needs of the laboratories and T&E centers to support the development of current and future weapon systems. Vision 21 will integrate the three concepts of reduction, restructuring, and revitalization.

Reduction focuses on current infrastructure with particular emphasis on the elimination of old, high-maintenance, and inefficient facilities while retaining critical capabilities for the future. Options will include reducing the infrastructure costs of both the laboratories and the T&E centers. One option will reflect reductions in both laboratory and T&E center infrastructure by at least 20 percent beyond the Base Realignment and Closure 1995 (BRAC) by 2005.

Restructuring, to begin with intra-Service restructuring will include activities such as business process reengineering. Restructuring will also place a strong emphasis on cross-Service reliance.

Revitalization will focus on modernizing aged critical laboratories and T&E centers. The emphasis will be on technologies of the twenty-first century, cross-Service sharing, improving efficiencies, and reduced cost of operation and maintenance. [10]

Additional pressure for downsizing and consolidation was added by a National Science and Technology Council (NSTC) report that recommended developing a plan for improving efficiencies and consolidations within the DoD laboratories. The recommendations, endorsed and forwarded by the President to DoD, were based on the NSTC's observations that the DoD had not made sufficient progress in cross-Service integration or exploiting the BRAC process as a downsizing tool.[11]

While Vision 21 has a stated goal of pursuing all three of the above actions in parallel, the primary emphasis to date has been in the reduction area. The reduction strategy is key to achieving the cost savings necessary to revitalize the RDT&E infrastructure. All the Services have vigorously pursued intra-Service strategies to meet the 20 percent reduction goal. Both the Air Force S&T community and T&E community developed draft recommendations for internal consolidation activities. Some of these recommendations have already been implemented by the Air Force, while others are still under study.

The S&T community has addressed internal reductions through restructuring actions. The four laboratories, which were previously assigned to the Product Centers, have been merged into a single Air Force laboratory called the Air Force Research Laboratory (AFRL). This laboratory structure includes the Air Force Office of Scientific Research (AFOSR) and reports to a laboratory commander who is also the Air Force Technology Program Executive Office. The former laboratory command and planning staffs have been merged with the HQ AFMC/ST staff to form a smaller, integrated investment planning and command staff. Additionally, the over 45 directorates and 200 divisions which existed within AFOSR and the four laboratories will be realigned into approximately ten directorates and 50 divisions. As a final effort, technology portfolios would be realigned within the new directorates, to new locations in the Air Force, or to other Services as appropriate.[12]

While the S&T effort concentrated on a major realignment of the laboratories and a significant reduction in command structure, the T&E community faced difficult problems in achieving internal reductions and savings. Many consolidation actions had occurred

both as part of the BRAC process and through Air Force initiatives. The Air Force T&E infrastructure had consolidated to a core of three test centers (Edwards AFB, Eglin AFB, and Arnold AFB) and one operating location (Holloman AFB). Additional Air Force T&E reductions will require eliminating or privatizing capabilities. For example, Air Force test capabilities that duplicate a contractor's capability for developing systems would be eliminated. Other capabilities would be outsourced if at all possible. A greater emphasis would be placed on computational modeling and simulation, which holds promise for future efficiencies in the test process, but would require significant investments in the near term to mature computer models.[13] Despite the above actions, significant T&E savings through intra-Service actions are not readily apparent. Major savings in the DoD T&E infrastructure appear to only be achievable through major inter-Service consolidation.

The Air Force and the Navy both have open-air ranges and facilities for testing integrated aircraft systems. The potential for consolidation of these assets is a highly contentious issue between the Services, but it is also the largest potential source of reductions and savings achievable in the T&E infrastructure. Each Service believes their needs are unique enough to warrant separate Air Force and Navy flight test capabilities. Both the Air Force and Navy believe they could satisfy the needs of the other Service. This impasse will be difficult to overcome.

A key aspect of any significant reductions or restructuring as a result of the Vision 21 will be legislation to allow it to happen. The Vision 21 effort is seeking "BRAC-like" legislation to facilitate the process. The Secretary of Defense request for two more BRAC rounds in the latest Quadrennial Defense Review is also a factor. Should

additional BRAC rounds be approved, the Vision 21 process may be truncated under the assumption that laboratory and T&E infrastructure would be sufficiently downsized in future BRACs. The push for reductions and efficiency continues to be a theme in the latest national planning documents.

National Strategies, Jointness, and Commercialization

The reduction, restructuring, and revitalization goals addressed in the Vision 21 process are supplemented by national technology strategies which emphasize joint warfighting requirements and a national technology base. The National Security Science and Technology Strategy lists four strategy elements to guide science and technology investments.[14] The Joint Staff and the Joint Requirements Oversight Council developed the joint warfighting capabilities mentioned above, capturing the requirements in five capability areas.[15]

To address the strategy elements and meet the joint warfighting capabilities, the strategic investment priorities stress four considerations in making decisions about which technologies should be pursued. The first of these considerations is affordability. This area addresses not only affordability of a recommended technology, but investing in technologies making DoD systems more affordable and modernizing existing systems. Two current examples are technology developments to reduce production fabrication costs, and microelectronic "smart" sensors to monitor equipment during operations and provide maintenance cues.[16]

The second consideration area is dual use. The goal is achieve a single, common industrial base for military and civilian use. The science and technology program will assist in building the industrial base by using commercial practices, processes and

products, and by developing technology for military and commercial products, when possible.[17]

The third consideration is accelerated transition of technologies to systems in development. With the ever-increasing availability of advanced technologies in the world marketplace, this consideration seeks to insure DoD can quickly integrate new technologies into the system development process. One tool for facilitating this integration is the Advanced Concept Technology Demonstration (ACTD) which allows operators to evaluate new technologies earlier in the development process.[18]

The final consideration is the continuation of a strong technology base. This consideration incorporates the need for a long-term view beyond current threats, situations, and budgets. A strong technology base addresses the need for basic and applied research, and a core experience base of scientists and engineers to develop the future military technologies.[19]

Summary

Assessing the scorecard at this point in time:

Innovation……………………………………**X**……………..Efficiency
Revolution………………………………………………**X**…..Improvement
Capability………………………………………**X**…………Threat
Independence…………………………………**X**……..…..….Reliance
Vision…………………………………………**X**…………….Requirements

The development of *New World Vistas* 50 years after *Toward New Horizons* was more than a symbolic gesture. The Chief of Staff in particular wanted to look forward and press for a long-range vision for the Air Force. The SAB addressed a broad range of technologies that the Air Force would need for the future, and also addressed areas in

which the Air Force should rely on commercial development. *New World Vistas* presents a possible approach for the Air Force to pursue in technology development.

The ability of the Air Force to implement *New World Vistas* will be complicated by other developments within the DoD community. Vision 21 and/or future BRAC rounds present a significant threat of reducing and restructuring the RDT&E infrastructure. The drive for a reduced and efficient infrastructure is likely to produce greater inter-Service reliance for technology products. The potential for BRAC and Vision 21 actions are a considerable distraction to the laboratories and T&E centers, and promote the potential for unhealthy competition for resources and workload to strengthen one institutions position at the expense of another.

The near-term focus brought on Vision 21 and BRAC are further reinforced by national science and technology strategies emphasizing affordable systems and dual-use technologies. While these strategies do not preclude innovation and long-term visions, they also do not emphasize them. There is clearly intent to minimize the national industrial requirement while maximizing the payoff to both military and commercial uses – but the cost to the future warfighter is unclear.

Notes

[1] Fogleman, Ronald R. and Widnall, Sheila E., Memorandum to Dr. McCall, *New World Vistas Challenge for Scientific Advisory Board (SAB)*, 29 Nov 94. The specific requirement was to:

1. Predict how the explosive rate of change will impact the Air Force over the next ten years.
2. Predict the impact of these technological changes on affordability of Air Force weapon systems and operations.
3. Predict S&T areas where the Air Force can minimize investments and rely on commercial development efforts.
4. Predict S&T areas the Air Force will have to develop, where no commercial market exists or is likely to develop.

Notes

5. Offers advice as to whether the Air Force lab structure is consistent with these new vistas, and what changes, if any, should be made.
6. Offer advice as to whether the current SAB charter is consistent with these new vistas, and if any changes are required.
7. Evaluate the proposals in light of how the Air Force contributes to the joint team.

[2] Scientific Advisory Board, *New World Vistas, Summary Volume*, (Washington, DC: Scientific Advisory Board, December 1995), 57. The six capability areas identified are:

1. Global Awareness
2. Dynamic Planning and Execution Control
3. Global Mobility in War and Peace
4. Projection of Lethal and Sublethal Power
5. Space Operations
6. People

[3] Ibid., 52-53. The revolutionary technologies identified are:

1. UCAV structures and engines – including hypersonic operation
2. Large lightweight structures for optics and antennas
3. High power, short wavelength lasers with emphasis on phased arrays
4. High power radio frequency sources
5. Active and IR stealth
6. Point of use delivery starting with low cost precision airdrop
7. Automated, reusable space launch vehicles with "airplane-like" operations
8. Distributed satellite vehicles and sensors
9. High precision, jam resistant GPS
10. Human-Machine interactions
11. Information munitions

[4] Ibid., 53.

[5] Ibid., 63. The recommendations of areas to stop or curtail work are:

1. Stop buying bandwidth to the Theater
2. Stop software development of software tools
3. Stop development of compilers
4. Stop mandatory use of Ada
5. Stop selective availability of GPS
6. Stop environmental protection research in Air Force labs
7. Stop aircraft cockpit design work – depend on aircraft manufacturers
8. Stop ejection seat research and development – depend on aircraft manufacturers
9. Rethink MILSTAR
10. Stop military only launch access to space – exploit commercial systems
11. Rethink the design of and investment in dedicated Military Satellite Communication Systems

Notes

[6] Ibid., 63-64.

[7] Ibid., 49-50.

[8] Ibid., 68.

[9] National Defense Authorization Act, FY 1996.

[10] Department of Defense, *Vision 21: The Plan for 21st Century Laboratories and Test and Evaluation Centers of the Department of Defense*, n.p. On-line. Internet. Available from: http://www.dtic.mil/labman/vision21/.

[11] Ibid.

[12] Unpublished USAF Air Staff study regarding the restructuring of Air Force laboratories and test centers. The author was a primary author of the test center section. Latest draft of the unpublished report: November 1996.

[13] Ibid.

[14] Office of the President, *National Security Science and Technology Strategy*, n.p. On-line. Internet. Available from: http://www.whitehouse.gov/WH/EOP/OSTP/nssts/html/chapt2-plain.html. The four stategy elements are:

1. Maintain technological superiority in warfighting equipment.
2. Provide technical solutions to achieve the Future Joint Warfighting Capabilities.
3. Balance basic research and applied technology in pursuing technological advances.
4. Incorporate affordability as a design parameter.

[15] Ibid. The five joint warfighting capability areas are:

1. To maintain near perfect real-time knowledge of the enemy and communicate that to all forces in near-real time.
2. To engage regional forces promptly in decisive combat, on a global basis.
3. To employ a range of capabilities more suitable to actions at the lower end of the full range of military operations which allow achievement of military objectives with minimum casualties and collateral damage.
4. To control the use of space.
5. To counter the threat of weapons of mass destruction and future ballistic and cruise missiles to the continental United States and deployed forces.

[16] Ibid.

[17] Ibid.

[18] Ibid.

[19] Ibid.

Chapter 8

The Next Century

As the Air Force approached its fiftieth anniversary in 1997 and faced a new millenium, Air Force leadership set about to develop a vision to take the Air Force well into the twenty-first century. This vision would draw from the work of previous efforts such as *New World Vistas*, *Joint Vision 2010*, and *Air Force 2025*. Published in November 1996, *Global Engagement: A Vision for the 21st Century Air Force* presented a comprehensive view of the Air Force of the future. *Global Engagement* provides a framework for people, capabilities, and support structures for the future Air Force.

Global Engagement

The premise of *Global Engagement* is that the Air Force is undergoing an evolution from an air force to an air and space force to a space and air force. This evolution is both philosophical and technological. It requires airmen who can think in new terms and technology that provides new capabilities. Fundamental to this new vision is the concept that, "in the 21st Century it will be possible to find, fix or track and target anything that moves on the surface of the earth."[1] This concept is based on fundamental assertions regarding the Air Force's role in future operations, Air Force people, a method for implementing the evolution, and Air Force infrastructure.

Global Engagement discusses several key operational concepts for the future Air Force. Among these are that the Air Force will be the prime force in space operations. Both the U. S. and potential adversaries will rely on space operations. The future Air Force will secure space for the U. S. for activities such as intelligence, communications, weapons guidance, and navigation. Operations that now focus on land, sea and air will ultimately move to the space arena.[2] The Air Force will also play a leading role in ballistic missile defense, orchestrating theater warfare, conducting information warfare, establishing forward presence, and providing robotic warfare.[3]

From the standpoint of Air Force personnel, *Global Engagement* foresees a uniformed force focused on truly military activities. All Air Force people will be "operators", in an expanded definition of the term from the current "rated" mindset. Non-operational support functions will be increasingly performed by civilians or outsourced to contractors.[4]

Implementing *Global Engagement* is a key part of the document itself. Two new processes are being institutionalized to support the evolution. The first is the Air Force Long Range Plan, which is a step in between a visionary statement and a yearly budget. The Long Range Plan will provide the blueprint and measuring stick for ensuring required capabilities are ready on time. A feature of this process will be a 25-year technology plan which supports the future capabilities. The Long Range Plan will be an iterative process, with the first plan published in 1997. In terms of RDT&E, the first Long Range Plan emphasizes reductions and consolidations. The laboratory goal was to reorganize and pursue joint Service laboratories. The T&E goal was to eliminate overlapping and redundant facilities, increase the use of computer modeling and

simulation to reduce flight test, and continue Air Force test expertise in aircraft, munitions, electronic combat, C4I, and space.[5]

The second major implementation tool is the creation of six battle labs, which are focused on reinvigorating the spirit of innovation within the Air Force. The six battle labs are coupled to the six core competencies of space, air expeditionary forces, battle management, force protection, information warfare, and unmanned aerial vehicles. The battle labs will look for new ways to use technology and new operational concepts and systems to enhance the use of air and space power.[6]

Finally, *Global Engagement* addresses key infrastructure requirements. In terms of RDT&E infrastructure, *Global Engagement* clearly supports aggressive reductions. Consolidations into Centers of Excellence and Joint Centers of Excellence are proposed as key aspects to reducing the cost of RDT&E infrastructure. Outsourcing and privatization and expanded use of computer modeling and simulation are also proposed as cost saving measures.[7]

Future Trends

The Air Force commitment to a future vision and a spirit of innovation faces significant challenges. While *Global Engagement* acknowledges and even encourages personnel and infrastructure reductions, the combined effect these reductions, coupled with future budget realities, creates a difficult problem for technology development.

The expected personnel reductions in RDT&E were previously discussed in Chapter 6. Both S&T and T&E will experience over 35 percent declines in personnel from 1989 to 2003. These reductions, compounded by reductions already performed or programmed, will leave gaps in the Air Force intellectual capital. These reductions also

require further dependence on commercial, other DoD, and NASA research efforts to fill the gap.

Infrastructure reductions are yet to be determined, but the emphasis on reduction is undeniable. The Air Force, the DoD, and Congress are all committed to a smaller defense RDT&E infrastructure. Vision 21 and/or future BRAC rounds will almost certainly reduce the number of RDT&E facilities within all the Services. In addition, activities are underway with industry and NASA to work towards a single U. S. industrial base. The Under Secretary for Acquisition and Technology within OSD has reinvigorated the Aeronautics and Astronautics Coordination Board (AACB) to work with industry and NASA on technology and infrastructure issues. The Air Force and NASA have begun efforts to establish joint control of aerospace test facilities. This activity extends to building new facilities as well. The DoD, NASA, and industry discussed a potential consortium funding and management arrangement for a new $1.2 billion wind tunnel. The project was not pursued beyond initial design stages, but future efforts will require a similar consortium if current budget trends continue.[8] All these actions work towards a future facility base that minimizes overlap and redundancy.

If the Air Force is to rely on other sources for RDT&E activity, then DoD and national RDT&E budget trends are important. Unfortunately, the future budget projections compound the problem. The charts in Appendix C show the budget trends vividly, as a synopsis:

1. National defense R&D is falling to levels not seen since the Truman and early Eisenhower years (as a percentage of total outlays).
2. Private industry R&D perhaps doubles federal government total R&D. Defense is approximately $37 billion of the $70 billion federal R&D outlay.
3. Defense basic and advanced research outlays are small and declining.

4. Defense investments in developmental R&D (near term efforts) are far greater than basic and applied R&D.
5. Investments in RDT&E facilities are virtually non-existent.
6. Air Force RDT&E funding is programmed to decline until 2003.

The significant increases in private industry R&D do not necessarily bode well for leveraging long term defense needs. Private industry has greater interest in near-term research providing return on investment as quickly as possible. Investment in high risk, high expense, long term efforts are less desirable from a business standpoint.

Summary

Recent actions by the Air Force have introduced a renewed spirit of vision and commitment to innovation. Major efforts such as *Global Engagement* and the Air Force Long Range Plan show intentions of renewed emphasis on planning and future needs.

While the Air Force has set the stage for ambitious changes in future operational capabilities, the ability to implement the new vision faces significant obstacles. Reductions in funding, personnel and infrastructure will make broad technological progress a more difficult task than in the past. The emphasis on joint capabilities and a single national industrial base create planning and implementation challenges.

The recent trends established lead to a probable near-term future scenario as follows:

Innovation……………………………………**X**……………..Efficiency
Revolution………………………………………**X**………..Improvement
Capability…………………………**X**..…………… …………Threat
Independence……………………………………...…..**X**….Reliance
Vision………………………**X**………………… ……...…….Requirements

The above projection is based on a number of assumptions:

1. DoD policy continues to emphasize dual-use technology development
2. Continued budget declines. At best, RDT&E “holds its own”.

3. No relief from current projected personnel declines
4. Vision 21 or BRAC rounds (or both) take place
5. Continued emphasis on business and commercial practices
6. PPBS unchanged in structure or emphasis
7. No significant technological threat emerges

Global Engagement postulates an evolutionary rather than revolutionary approach to the future. Even an evolutionary approach will face significant challenges to implementation based on the current trends in the capability needed. The path to the future will require an understanding of the past, a proactive approach to planning, and the ability to make difficult choices with imperfect information.

Notes

[1] U. S. Air Force, *Global Engagement: A Vision for the 21st Century Air Force*, (Washington, DC, November 1996), 1.

[2] Ibid., 7.

[3] Ibid., 9-17.

[4] Ibid., 18.

[5] The author was involved in the Long Range Plan process from its beginning until his departure from the Air Staff in July, 1997. The author helped develop the T&E goals and was involved in the laboratory/acquisition goals also.

[6] *Global Engagement*, 9.

[7] Ibid., 23.

[8] The author was involved in all the processes mentioned in this section. The author participated in briefings to the CSAF, SECAF, and Under Secretary for Defense (Acquisition and Technology) regarding the National Wind Tunnel Complex.

Chapter 9

Analysis, Conclusions and Recommendations

An examination of the scorecards with a few pertinent facts about the period in time will facilitate analysis of Air Force RDT&E.

Inter-war years:

Innovation……**X**……………………………………………..Efficiency
Revolution………………………………………**X**………..Improvement
Capability………**X**……………………………………………Threat
Independence……………………………………..….**X**….Reliance
Vision………..**X**……………………………………………Requirements

Characterization: A time of low funding, low manning, few facilities. No real threat in terms of air power. A strong vision within the Air Corps of the role of air power, and in particular strategic bombing, in any future conflict.

World War II:

Innovation…………………………………………**X**……..Efficiency
Revolution……………………………………………**X**…..Improvement
Capability………………………………….**X**……………Threat
Independence……………………………**X**………..…..….Reliance
Vision…………………………**X**…………………………Requirements

Characterization: Shift in emphasis to very near-term needs of getting aircraft production operating and modifying current aircraft designs as required. Influx of funding brings new facilities for RDT&E. Strategic bombing vision tempered by wartime requirements.

Post World War II:

Innovation……**X**……………………………………………..Efficiency
Revolution…………………………**X**……………………..Improvement
Capability………**X**……………………………………………Threat

Independence…………………**X**…………………….…..….Reliance
Vision……………………**X**…………………………….Requirements

Characterization: *Toward New Horizons* brought a new vision warmly embraced by General Arnold and others. Severe funding and personnel reductions would force the new Air Force into a more conservative approach. Organizational problems lingered with the new ARDC and AMC.

Early Cold War:

Innovation……**X**…………………………………………..Efficiency
Revolution……………**X<---------------------------X***……..Improvement
Capability……………………………**X------------→X***..……Threat
Independence……………**X**…………………….…..….Reliance
Vision…………………………………**X**………………Requirements

* The shift to left reflects the change to develop a revolutionary capability – the ICBM – in response to the shift to the right in the threat – the perceived Soviet lead in ICBM development.

Characterization: Austere times and no global peer restricted the Air Force's ability and desire to pursue long-range technologies, such as the ICBM. Emergence of perceived Soviet ICBM threat with hydrogen warheads drove the Air Force to pursue ICBM technology. Significant investments to support ICBM development and testing made at Vandenburg AFB.

1960s Through 1980s:

Innovation……**X**…………………………………………..Efficiency
Revolution………………………**X**……………………..Improvement
Capability……………………………………………**X**………Threat
Independence…………………**X**…………………….…..….Reliance
Vision…………………………………**X**………………Requirements

Characterization: A time of growth in funding, manpower, and facilities for RDT&E. Primarily threat-based developments were balanced between revolutionary systems and improvements in current technology. Greater OSD influence and PPBS tempered visionary approaches with requirements.

Early 1990s:

Innovation…………………………………X……………..Efficiency
Revolution……………………………………….X……..Improvement
Capability………………………………………X………Threat
Independence………………………X……………..…..….Reliance
Vision……………………………………….X………….Requirements

Characterization: Collapse of Soviet Union reduced threat to U.S. Significant budget reductions, personnel reductions, and base closures begin. Greater OSD influence and inter-Service reliance begins to take shape. Budget reductions and lack of threat drives conservative approach to technology development and rise of "dual-use" as a goal.

Today:

Innovation…………………………………X……………..Efficiency
Revolution…………………………………………X…..Improvement
Capability……………………………………X…………Threat
Independence………………………………X……..…..….Reliance
Vision……………………………………X……………Requirements

Characterization: Continued budget reductions and mandates for greater reliance among Services for technology development and infrastructures. Investments in efficient production capabilities and dual-use are strong policies. Defense technology base eroding with less declines in budgets. *New World Vistas* proposes a new vision, but near-term requirements still dominate the budget process.

Early 21st Century:

Innovation……………………………………X…………..Efficiency
Revolution……………………………………….X……..Improvement
Capability……………………………X……………………Threat
Independence…………………………………...…..X….Reliance
Vision…………………………X………………………….Requirements

Characterization: A renewed emphasis on a future vision to evolve to a Space and Air Force, coupled with an institutionalized process (Long Range Plan), hold promise for renewed innovation. Emphasis on consolidation and efficiency, reduced funding, and reduced manning are significant roadblocks to implementation.

Analyzing the Trends

The above characterizations reflect a number of trends in DoD and Air Force policy. With regards to innovation versus efficiency, the Air Force has generally emphasized innovative technology approaches. World War II was an anomaly, when near-term improvements and production capabilities took precedence. A trend towards efficiency is also evident today, as dual-use and reducing costs of systems are important technology drivers. In addition to the national and DoD emphasis on dual-use, the general movement of government agencies towards business practices and metrics pressures innovation and revolution.

The Air Force has tended to prefer improvements in technology versus revolutionary technology development. Perhaps the best balance of revolution and improvement was in the 1960s to 1980s. This time period had the funding, infrastructure, and personnel to pursue the system improvements and revolutionary technologies so successful in the 1990 Gulf War. The current trend in budget and personnel reductions bode poorly for revolutionary technologies, as improvements tend to be less risky, more near-term, and easier to defend in budget drills. Furthermore, the rejoining of AFSC and AFLC into AFMC may once again place research and development and logistics support at odds in reduced budget environments.

The Air Force has tended to be strongly threat driven in approaching technology, and with good reason. The Soviet Union was a worthy adversary from the 1950s to 1990. Furthermore, a definable threat was important in the budget battles after the implementation of the PPBS. The Air Force today faces a choice of pursuing capabilities that can mitigate the emergence of future threats, or continuing a near-term threat focus.

The movement from a mostly independent RDT&E posture to a highly reliant position may be the most difficult trend with respect to the Air Force's ability to pursue future technology. The potential for significant impact from Vision 21, Reliance, BRAC, and a future single national industrial base requires careful consideration.

The full implementation of the Reliance process coupled with Vision 21 and/or BRAC will be an important trend. If the "savings", as postulated in the Vision 21 tenants, are used for revitalization of the infrastructure, then there may be some benefits. If, as many fear, the savings are used to offset budget cuts and other requirements, then the benefit of some cost reductions are more than offset by the layers of bureaucracy currently inherent in the Reliance process.

Coupled with Reliance is the concept of a single, national industrial base. The goal is essentially to eliminate overlap between the governmental and commercial infrastructures. This concept has a number of difficulties in and of itself in terms of priorities between government and commercial efforts and facility investment priorities and cost sharing.

An additional factor influencing the efficacy of single national industrial base is the decline in the number of defense contractors. Chapter 3 discussed the role commercial aircraft manufacturers played in the development of technology during the 1920s and 1930s. The growing aviation industrial base made competition and innovation keys to survival. The Air Corps benefited from the depth and breadth of commercial organizations involved in aeronautical research. Recent mergers within the aviation industry have significantly reduced the number of major contractors. A Defense Logistics Agency projection shows a continued reduction in the future.[1]

As the number of contractors decrease, so too do the sources for R&D and the competition base for innovative approaches. This presents a serious problem for maturing technologies as well as basic development of technologies. This development, coupled with the DoD Reliance philosophy of eliminating overlap among Service laboratories will bring an increasing myopic view to basic research.

In terms of Air Force vision versus requirements, the projections of *New World Vistas*, *Global Engagement*, and the Air Force Long Range Plan all attempt in varying degrees to bring some long range recommendations into focus. The overwhelming Air Force and DoD mindset of focusing on requirements is difficult to overcome and will take a top level sustained commitment to the vision to bring any perceptible changes to the system.

Conclusions

If lessons can be learned from history, there are a number of parallels the Air Force should consider carefully in pursuing technology development for a twenty-first century Space and Air Force:

1. *The pressure of reduced budgets, personnel, and lack of world peer can lure the Air Force to think too near-term.* In the austere climate of the late 1940s, the Air Force focused too near-term in technology development, content in the assumption that no world peer would pose a significant threat for several years. The Soviet Union's development of the hydrogen bomb and perceived lead in ICBM development required a national commitment to insure security.
2. *The creation of AFMC once again brings research, development and procurement into competition with logistics and sustainment.* This is less of an issue than in the 1950s due to the "color of money" restrictions, PPBS, and multiple Program

Element structure for managing resources. But, there is a risk the near-term/far-term technology effort will swing too far to the near-term side to solve current system development, production, and sustainment problems.

3. *The current emphasis on creating a future vision for the Air Force will require long-term commitment and nurturing.* Even with a leader like Hap Arnold, the post World War II Air Force was not fully successful in embracing and pursuing the vision of *Toward New Horizons*. The creation of a long range planning office on the Air Staff by General Fogleman may help facilitate institutionalizing the vision of the future Air Force. Senior Air Force leadership must continue to look beyond today's Air Force.
4. *Today's emphasis on jointness presents many of the same challenges faced by the Army Air Corps of the 1920s and 1930s*. Today's joint environment is not unlike the War Department of the early years of the Army Air Corps. Just as the Army Air Corps had to both fit within the context of Army and, to a lesser extent, Navy strategies while fighting for the strategic bombardment vision; today's Air Force must fit it's future vision into the context of a joint future vision. At a technology development level, the future Air Force must also operate within the confines of the DoD Reliance structure eliminating overlap between Service technology development efforts, and a combined government and industry technology base.

The last conclusion is not intended to reflect a judgment about the value of jointness. In today's environment, jointness is an absolute imperative for military operations. But jointness also brings a bureaucracy and cross-Service competition that can stifle innovation. The key will be to minimize the bureaucracy and foster healthy competition. Furthermore, the Reliance process reduces the Air Force control of certain technology areas and increases OSD and other Service input to the Air Force technology program. This may reduce the "breadth" of research in given technology area and again bring additional bureaucracy to the process.

Before addressing recommendations, there are two areas to address that could have a significant impact, but which the Air Force is probably powerless to affect. The first area is the PPBS. The PPBS has instituted a structure for resource allocation. Unfortunately, as addressed in the recent National Defense Panel report, the first "P" is silent. The planning function of the PPBS is its weakest link, and the PPBS is used mostly to fuel the

budget process in the Pentagon. A renewed emphasis on the planning function would be beneficial to developing long-range strategies.[2]

The second area affecting Air Force RDT&E infrastructure is the Vision 21 and BRAC processes. The reductions and closures possible under a Vision 21 or BRAC scenario will affect the infrastructure available in the future, and places the laboratories and test centers in an unhealthy competition today. The possibility of closure or significant downsizing have driven organizations to aggressively pursue new capabilities and workload while sharing less information with other centers. Vision 21 and BRAC are forcing functions for competition in the wrong way and are harmful to the entire DoD RDT&E infrastructure. The only remedy will be completion of both efforts as soon as possible.

Recommendations

The easiest of all recommendations would be to increase funding for technology development and facilities, and increase manning levels. These recommendations are not very credible in light of the significant budget and personnel declines the Air Force is experiencing. As can be seen from the information in the appendices, the Air Force has attempted to protect RDT&E as a percentage of overall manning and budgets. There must continue to be a realization, however, that a healthy and robust RDT&E effort is not tied to overall budget levels. Unless mission areas are removed from the Air Force or from the RDT&E mission area, a sustained commitment for manpower and funding must continue.

To insure technology development and testing is accomplished in time for the Air Force of tomorrow, the Air Force of today should:

1. *Set a long-range vision and continue to sustain it.* The visionaries of the 1920s and 1930s stayed with the strategic bombing vision despite few resources and little support. The present Air Force needs to emulate this tenacity.
2. *"Stay the course" on the Long Range Plan.* It is the implementing mechanism for the vision. The long range planning process will take time to mature and become a comprehensive effort. The Air Force needs to give the process time to show results.
3. *Incorporate the results from New World Vistas in the Long Range Plan.* The Air Force needs to review the *New World Vistas* recommendations and fold the best recommendations into the Long Range Plan. The Air Force also needs to act on those recommendations aimed at stopping activities less relevant or that industry will do without Air Force influence.
4. *Refocus basic research funding to longer term, high payoff technologies.* Instead of investing in near-term increments to present technologies, the Air Force needs to seek out the next generation technologies to enable the future vision.
5. *Develop a long range vision and consortium approach for investing in new research and test facilities.* The investments for new facilities may be too expensive for any one organization to fund. Large ground test facilities, for example, may cost upwards of $1 billion and requires years of advocacy and construction. The Air Force, NASA, and industry will need to partner if new facilities are to be built.
6. *Prepare a technology development strategy that recognizes the greater reliance on other DoD and industry capabilities in the future.* The potential for a DoD laboratory and test center structure and a single government/industrial base is both a liability and an asset. The Air Force will have difficulty controlling its own technology destiny in this structure. The Air Force needs a game plan for insuring its needs are adequately addressed if this structure comes to pass.

The last two recommendations are of vital importance to the Air Force and the nation. The Air Force must move to control its own destiny within a new and different national industrial infrastructure. By taking an active role in shaping the national infrastructure, the Air Force can ensure its ability to defend the nation are not compromised in a time of declining budgets.

Notes

[1] Ivars Gutmanis and John F. Starns, "Whatever Happened to Defense Industrial Preparedness?", *Joint Forces Quarterly* (Summer 1997): 28. The postulated reductions are shown in the following table:

Notes

Aircraft	**1992**	**1996**	**2010**
Bombers	3	2	1
Fighters	5	4	2
Helicopters	4	4	2
Related Materiel			
Ballistic Missile Defense	6	4	3
Expendable Launch Vehicles	3	2	1
Satellites	5	4	3
Rocket Motors	8	8	3
Strategic Missiles	1	1	1
Tactical Missiles	8	8	8
Munitions			
Small Caliber	5	5	3
Cannon Caliber	5	5	3
Bombs	4	2	1
Fuses	22	13	8
Dispenser Munitions	2	2	2
Rockets/Warheads	4	3	2

[2] National Defense Panel, *Transforming Defense: National Security in the 21st Century*, n.p. On-line. Internet. Available from:

Appendix A

RDT&E BUDGET AUTHORIZATIONS[1]

FISCAL YEAR	R&D BUDGET AUTHORIZATION (THEN YEAR $B)	AIR FORCE BUDGET AUTHORIZATIONS (THEN YEAR $B)	R&D PERCENTAGE OF AIR FORCE BUDGET (%)
1947	0.125	1.2	**10.1**
1948	0.187	2.045	**9.1**
1949	0.206	1.83	**11.2**
1950	0.233	4.599	**5.1**
1951	0.286	20.429	**1.4**
1952	0.429	20.517	**2.1**
1953	0.511	17.788	**2.9**
1954	0.454	16.471	**2.7**
1955	0.427	19.183	**2.2**
1956	0.585	15.507	**3.8**
1957	0.697	17.677	**3.9**
1958	0.741	17.757	**4.2**
1959	0.814	18.767	**4.3**
1960	1.159	17.7	**6.5**
1961	1.553	20.1	**7.7**
1962	2.403	19.7	**10.3**
1963	3.216	20.4	**15.8**
1964	3.307	20.0	**16.5**
1965	3.081	19.4	**15.9**
1966	3.169	23.3	**13.6**
1967	3.063	24.3	**12.6**
1968	3.215	25.0	**12.9**
1969	3.021	25.9	**11.7**
1970	2.712	23.9	**11.3**
1971	2.876	23.0	**12.5**

1972	2.986	23.8	**12.5**
1973	3.325	24.7	**13.5**
1974	3.240	24.8	**13.1**
1975	3.328	26.0	**12.8**
1976	2.585	28.4	**9.1**
1977	3.621	31.1	**11.6**
1978	4.100	32.9	**12.5**
1979	3.900	34.9	**11.2**
1980	5.026	41.6	**12.1**
1981	7.085	52.4	**13.5**
1982	8.876	65.0	**13.6**
1983	11.220	73.4	**15.3**
1984	12.221	85.3	**14.3**
1985	14.402	96.5	**14.9**
1986	13.800	93.9	**14.7**
1987	13.718	91.6	**15.0**
1988	15.057	90.5	**16.6**
1989	14.678	95.3	**15.4**
1990	13.585	93.4	**14.5**
1991	11.957	90.9	**13.1**
1992	13.591	83.3	**16.3**
1993	14.532	79.1	**18.4**
1994	12.178	74.6	**16.3**
1995	12.057	74.1	**16.3**
1996	12.598	72.0	**17.5**
1997	11.656	71.8	**16.2**
Projections:			
1998	9.9	61.3	**16.1**
1999	9.4	62.9	**14.9**
2000	8.4	64.5	**13.0**
2001	8.1	67.5	**12.0**
2002	8.8	69.1	**12.7**
2003	9.6	70.8	**13.5**

Notes

[1] While data for this table was compiled from tables contained in various sources, the source data for all cases was the Budget of the United States for the various Fiscal Years.

Appendix B[1]

ARDC/AFSC Manning Levels

FY	AFSC OFF	AFSC ENL	AFSC TOT	AF TOT	MIL %	AFSC CIV	AF CIV	CIV %	TOT. %
1951	3,204	7,008	10,212	788,381	**1.29**	16,519	260,728	**6.33**	**2.55**
1952	4,537	14,964	19,501	983,261	**1.3**	18,898	309,663	**6.10**	**2.97**
1953	4,449	17,423	21,872	977,593	**2.24**	19,876	310,913	**6.39**	**3.24**
1954	4,788	17,033	21,821	947,918	**2.3**	17,165	298,592	**5.25**	**3.13**
1955	4,754	14,527	19,281	959,946	**2.0**	18,335	312,076	**5.87**	**2.96**
1956	*	18,522	18,522	909,958	**2.0**	22,141	348,230	**6.36**	**3.23**
1957	*	16,346	16,346	919,835	**1.77**	22,946	340,326	**6.74**	**3.12**
1958	5,615	19,372	24,987	871,156	**2.86**	23,777	315,806	**7.53**	**4.11**
1959	5,872	15,219	21,091	840,435	**2.51**	23,012	313,466	**7.34**	**3.82**
1960	6,078	15,351	21,429	814,752	**2.63**	22,887	307,449	**7.44**	**3.95**
1961	7,018	15,858	22,876	821,151	**2.78**	24,481	303,376	**8.07**	**4.21**
1962	8,300	17,944	26,244	884,025	**2.97**	32,234	306,181	**10.53**	**4.91**
1963	8,497	19,275	27,772	869,431	**3.19**	38,009	296,982	**12.8**	**5.64**
1964	10,002	19,790	29,792	856,798	**3.48**	37,233	289,724	**12.85**	**5.84**
1965	9,886	20,209	30,095	824,662	**3.65**	36,330	291,500	**12.46**	**5.95**
1966	8,767	19,606	28,373	887,353	**3.19**	32,279	306,915	**10.52**	**5.08**
1967	8,624	21,104	29,728	897,494	**3.31**	31,707	328,711	**9.64**	**5.01**
1968	9,414	21,038	30,452	904,850	**3.36**	32,236	322,661	**9.99**	**5.11**
1969	9,689	18,030	27,719	862,353	**3.21**	31,154	332,865	**9.36**	**4.93**
1970	9,480	18,402	27,882	791,349	**3.52**	29,577	306,323	**9.65**	**5.23**
1971	9,400	16,952	26,352	755,300	**3.49**	29,507	293,141	**10.06**	**5.33**
1972	9,400	18,618	28,018	725,838	**3.86**	28,979	279,897	**10.35**	**5.67**
1973	9,349	18,576	27,925	691,182	**4.04**	28,555	270,488	**10.56**	**5.87**
1974	9,601	17,749	27,350	643,970	**4.25**	29,219	280,812	**10.41**	**7.2**
1975	9,119	16,620	25,739	612,751	**4.2**	29,059	268,466	**10.82**	**6.22**
1976	9,092	16,740	25,832	585,416	**4.41**	28,250	248,225	**11.38**	**6.48**
1977	9,148	15,049	24,197	570,695	**4.24**	27,622	243,810	**11.33**	**6.36**
1978	9,125	16,281	25,406	569,712	**4.46**	26,531	240,182	**11.05**	**6.41**
1979	8,939	16,573	25,512	559,455	**4.56**	25,530	234,249	**10.9**	**6.43**

1980	9,358	15,955	25,313	557,969	**4.54**	25,923	233,132	**11.12**	**6.48**
1981	9,484	14,877	24,361	570,302	**4.27**	26,794	235,014	**11.4**	**6.35**
1982	10,104	14,812	24,916	582,845	**4.27**	26,453	236,996	**11.16**	**6.26**
1983	11,244	15,849	27,093	592,044	**4.58**	26,473	240,977	**10.98**	**6.43**
1984	11,910	15,689	27,599	597,125	**4.62**	27,598	242,622	**11.37**	**6.57**
1985	12,488	15,868	28,356	601,515	**4.71**	28,582	253,333	**11.28**	**6.66**
1987	10,970	13,924	24,894	607,035	**4.10**	28,465	254,446	**11.19**	**6.19**
1988	10,458	13,221	23,679	576,446	**4.11**	27,518	243,110	**11.32**	**6.25**
1989	10,463	13,283	23,746	570,880	**4.16**	28,769	250,840	**11.47**	**6.39**
1990	9,422	12,751	22,173	535,233	**4.14**	25,091	239,820	**10.46**	**6.09**
1991	8,737	12,758	21,495	510,432	**4.21**	22,942	225,001	**10.19**	**6.04**

* Only combined officer and enlisted strengths were available for these years.

Note: Manning levels are for entire ARDC/AFSC commands, including acquisition program offices and headquarters personnel in addition to personnel assigned to laboratories and test centers. A listing of laboratory and test center manning only was unavailable. While skewed because of the additional personnel, the chart does provide a top level review of Air Force personnel trends for the two commands charged with the research and development of systems. AFSC and AFLC joined into AFMC in 1992, thus figures after 1991 would be useless due to the addition of the Logistics Center manpower.

Notes

[1] SOURCES: Gorn, *Vulcans Forge,* Appendix 4-2; Statistical Digest of the United States Air Force (Washington, DC: Fiscal Years 1947-1951)

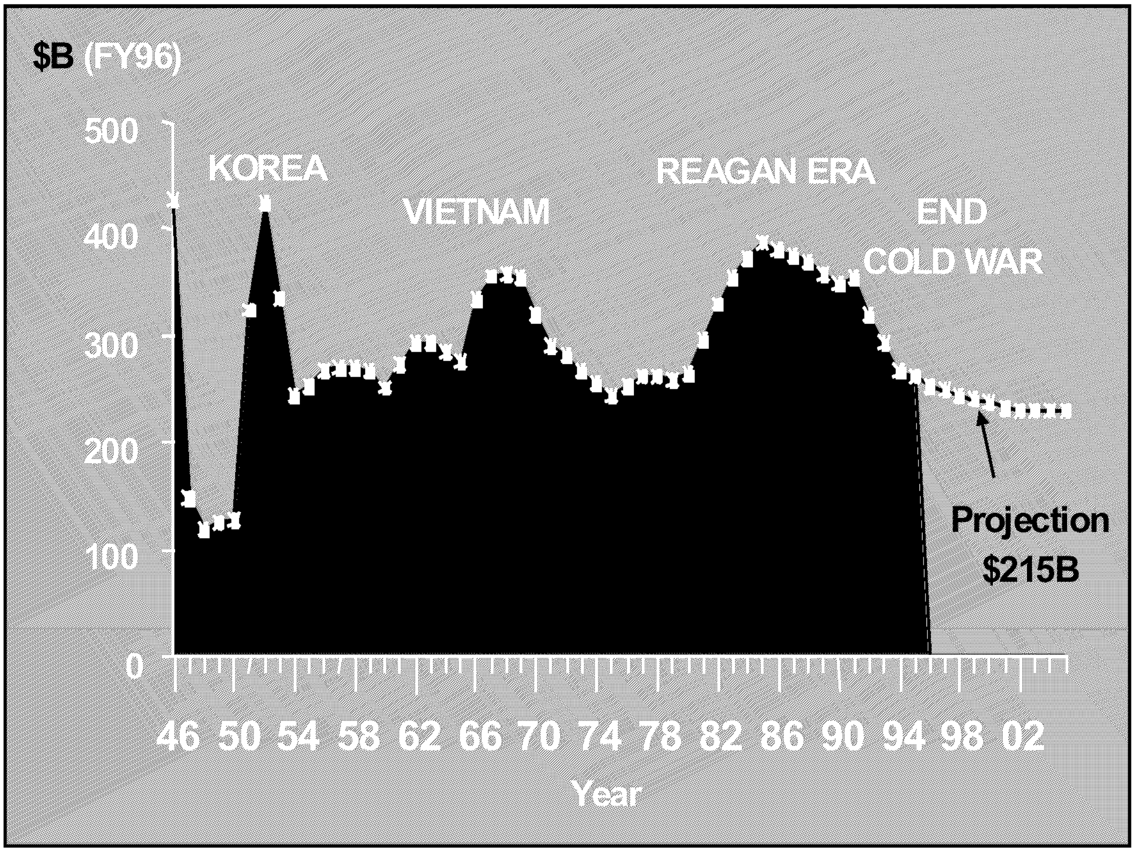
Appendix C

DoD, Air Force, and RDT&E Future Budget Trends[1]

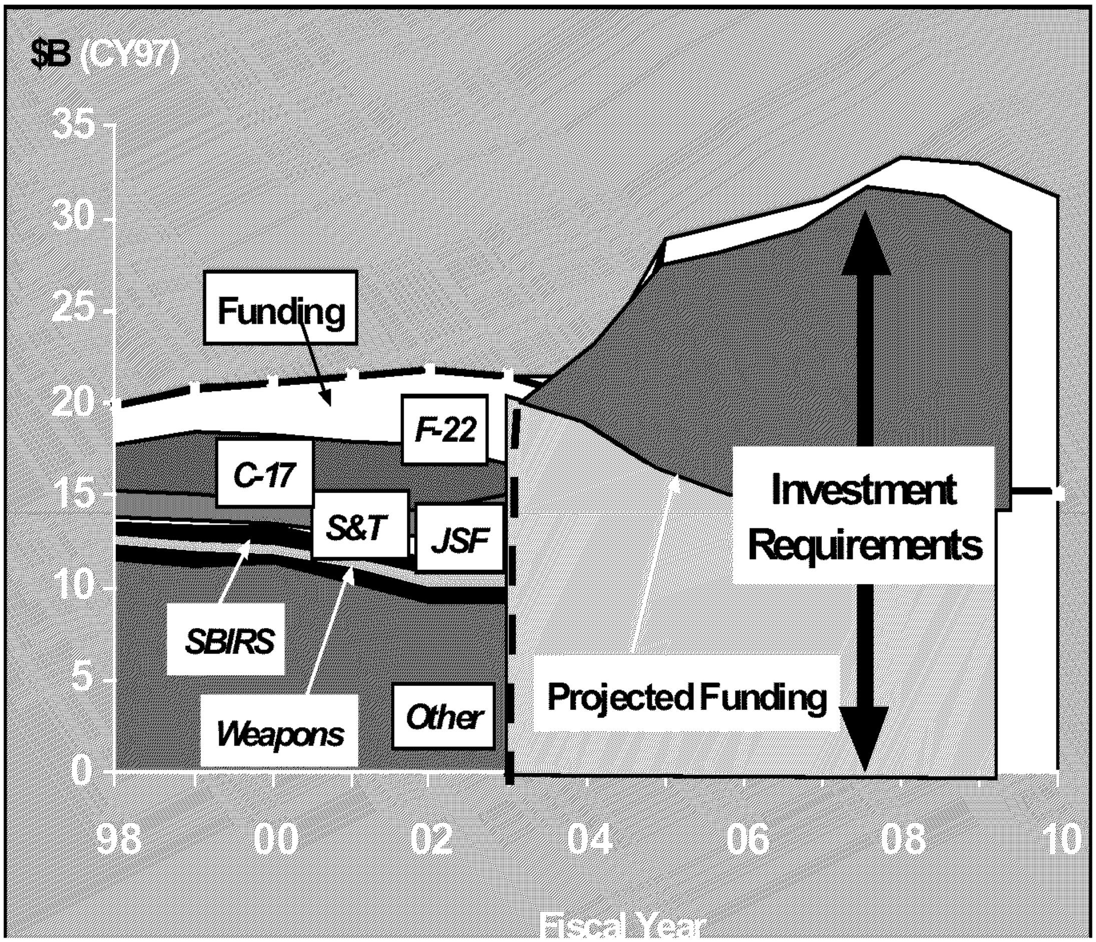
Notes

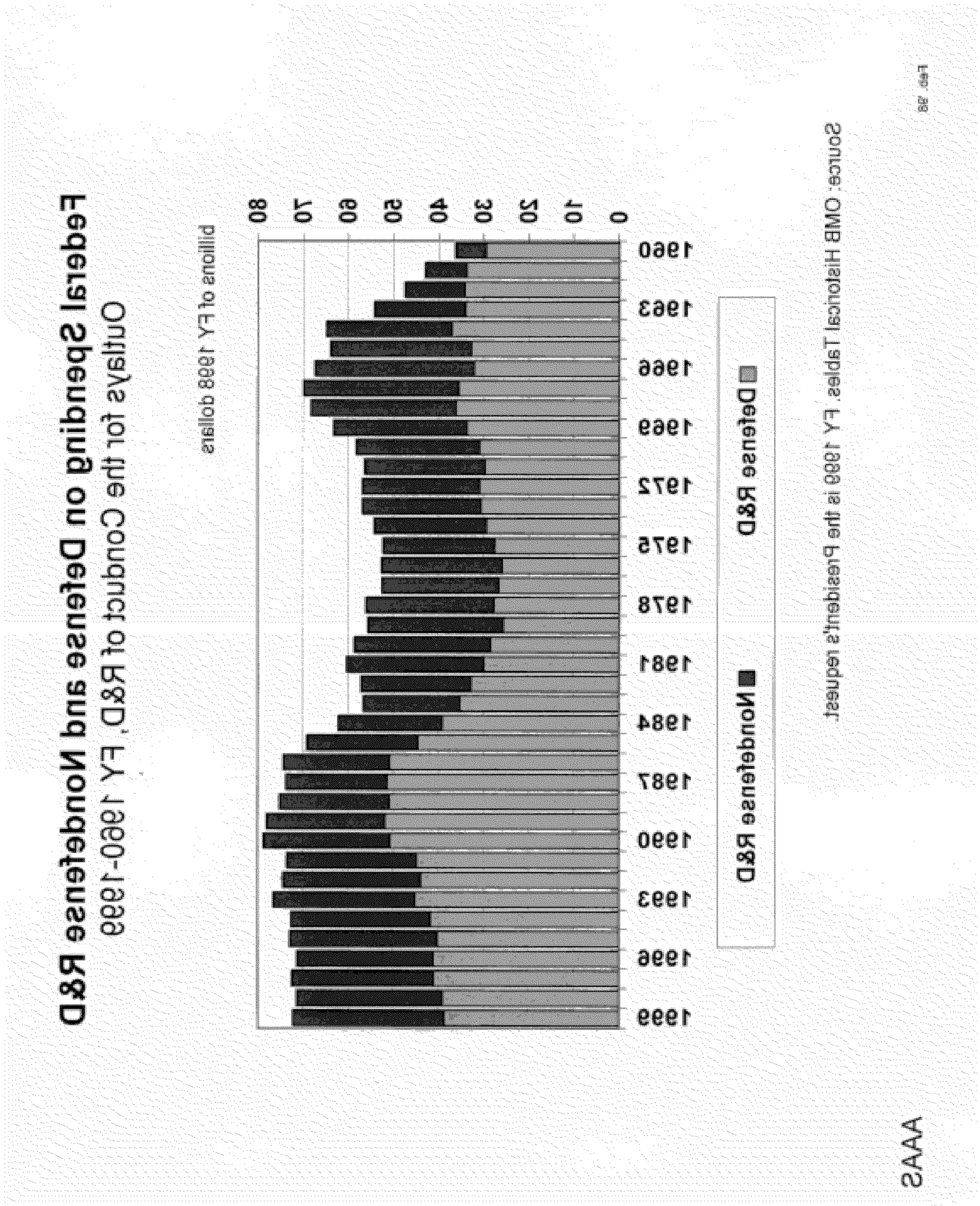
[1] SOURCES: American Association for the Advancement of Science, *Historical Tables of R&D*, n.p. On-line. Internet. Available from: http://www.aaas.org/spp/dspp/rd/.; HQ USAF/PES and AFMC/XP briefings using Information derived from the Budget of the United States.

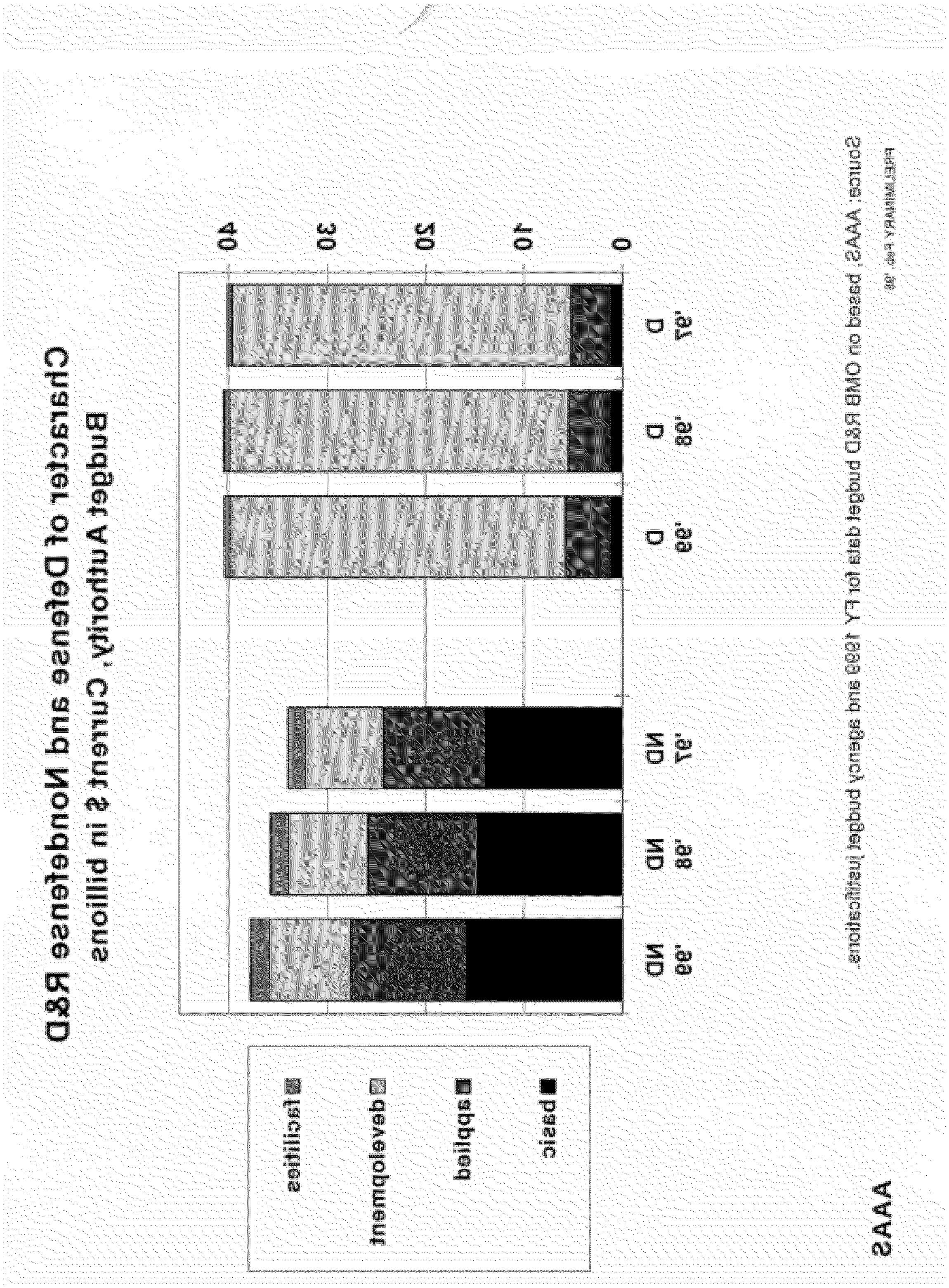
DoD Funding Trends

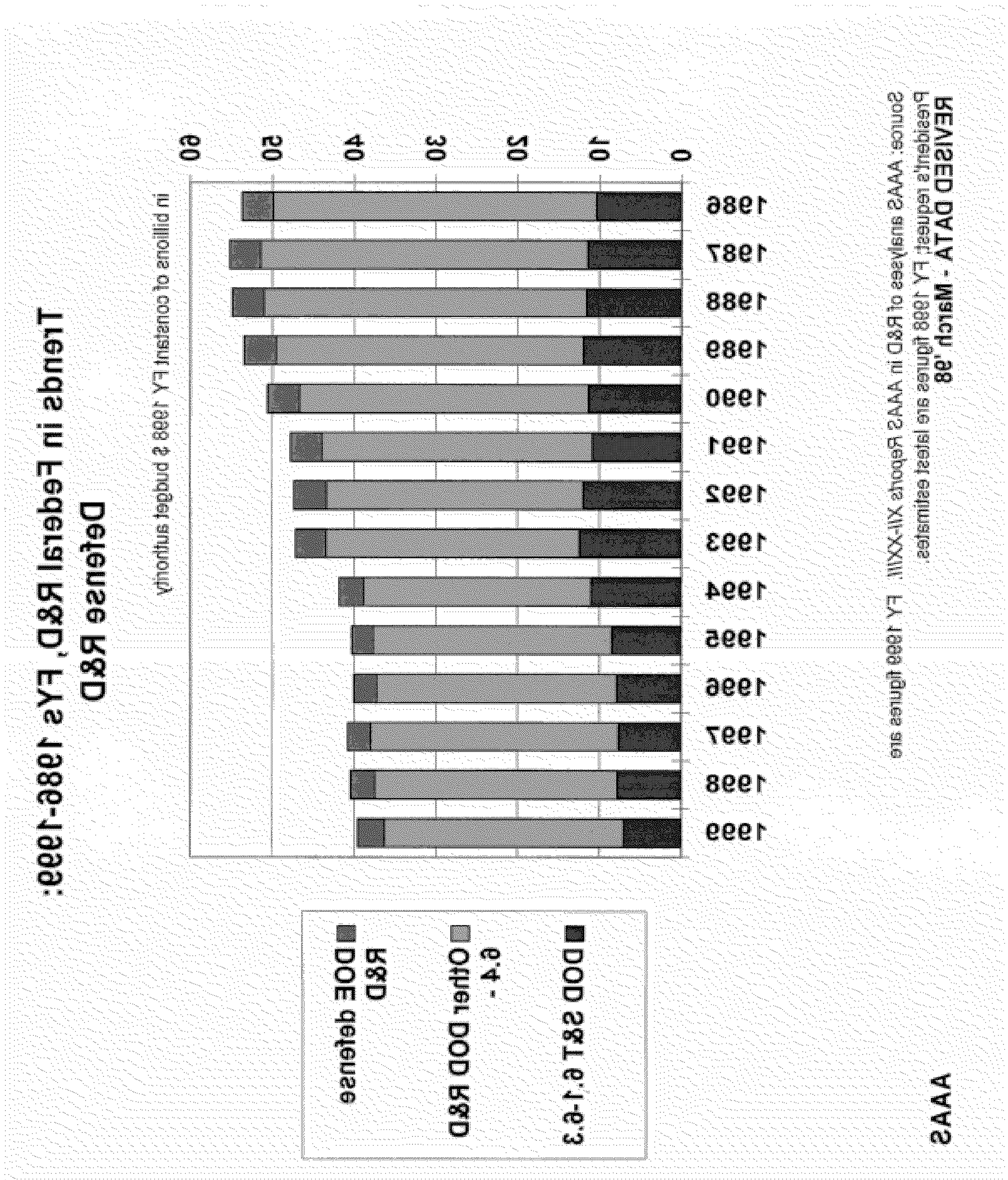


The Investment Challenge

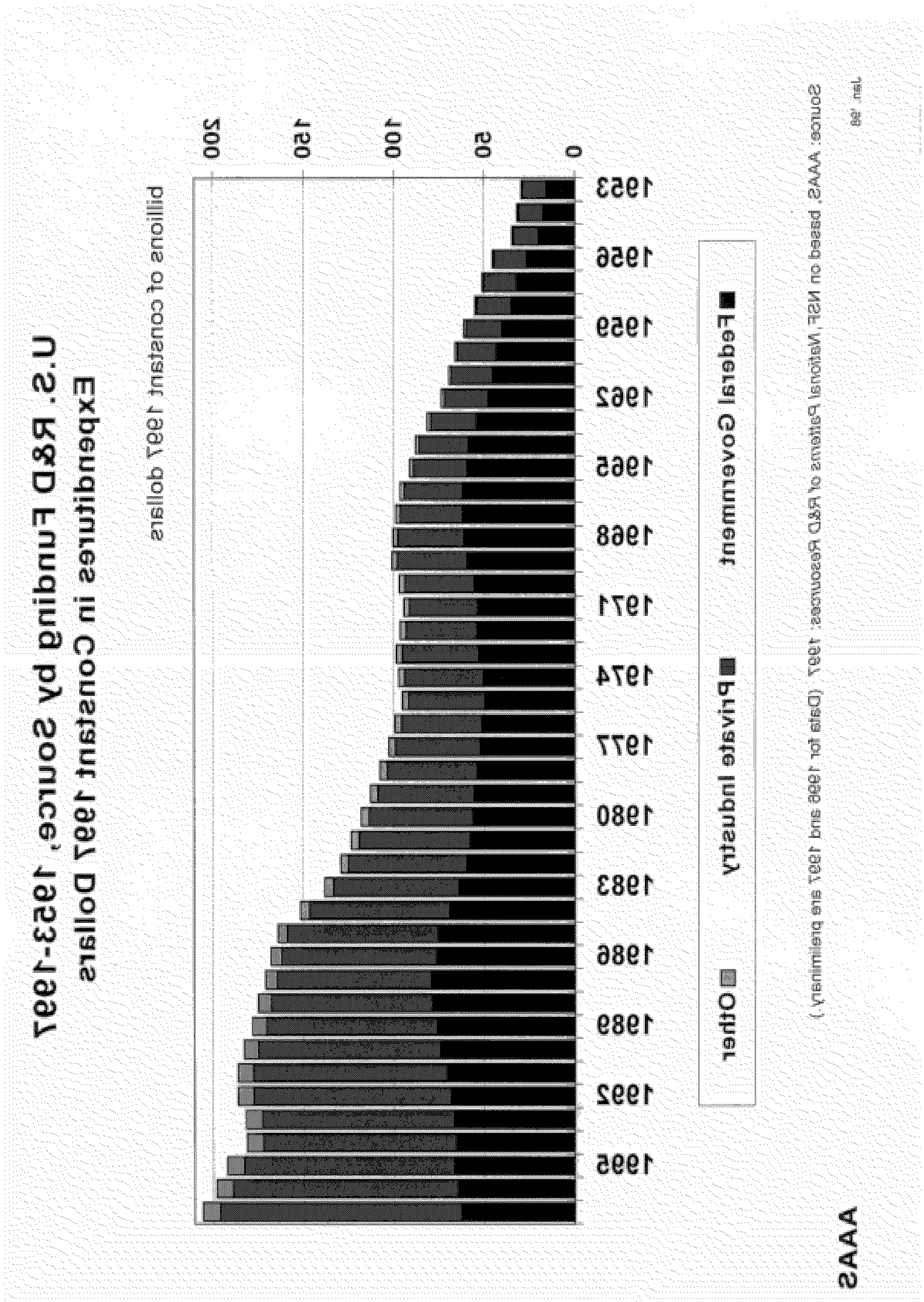



Federal Spending on Defense and Nondefense R&D
Outlays for the Conduct of R&D, FY 1960-1999
billions of FY 1998 dollars
0
10
20
30
40
50
60
70
80
1960
1963
1966
1969
1972
1975
1978
1981
1984
1987
1990
1993
1996
1999
Defense R&D
Nondefense R&D
Source: OMB Historical Tables. FY 1999 is the President's request.
Feb. '98
AAAS


Character of Defense and Nondefense R&D
Budget Authority, Current $ in billions
basic
applied
development
facilities
0
10
20
30
40
ND '99
ND '98
ND '97
D '99
D '98
D '97
Source: AAAS, based on OMB R&D budget data for FY 1999 and agency budget justifications.
PRELIMINARY Feb. '98
AAAS



Trends in Federal R&D, FYs 1986-1999:
Defense R&D
in billions of constant FY 1998 $ budget authority
DOD S&T 6.1-6.3
Other DOD R&D 6.4 -
DOE defense R&D
Source: AAAS analyses of R&D in AAAS Reports XII-XXIII. FY 1999 figures are President's request; FY 1998 figures are latest estimates.
REVISED DATA - March '98
AAAS



U.S. R&D Funding by Source, 1953-1997
Expenditures in Constant 1997 Dollars
billions of constant 1997 dollars
200
150
100
50
0
1953
1956
1959
1962
1965
1968
1971
1974
1977
1980
1983
1986
1989
1992
1995
Federal Government
Private Industry
Other
Source: AAAS, based on NSF, National Patterns of R&D Resources: 1997. (Data for 1996 and 1997 are preliminary.)
Jan. '98
AAAS

Glossary

AAF	Army Air Force
ACTD	Advanced Concept Technology Demonstrator
AEDC	Arnold Engineering Development Center
AFLC	Air Force Logistics Command
AFMC	Air Force Materiel Command
AFOSR	Air Force Office of Scientific Research
AFSC	Air Force Systems Command
AFTEO	Air Force Technology Executive Officer
AMC	Air Materiel Command
ARDC	Air Research and Development Command
ASTF	Aeropropulsion Systems Test Facility
BRAC	Base Realignment and Closure
C4I	Command, Control, Communication, Computers, Information
DCS	Deputy Chief of Staff
DDR&E	Director, Defense Research & Engineering
DOD	Department of Defense
FYDP	Future Year Defense Program
GOCO	Government Owned, Contractor Operated
ICBM	Intercontinental Ballistic Missile
IWSM	Integrated Weapon System Management
NACA	National Aeronautics Coordinating Agency
NASA	National Aeronautics and Space Administration
NSTC	National Science and Technology Council
OTA	Office of Technology Assessment
OSD	Office of the Secretary of Defense
PPBS	Planning, Programming and Budgeting System
QDR	Quadrennial Defense Review
R&D	Research and Development
RDT&E	Research, Development, Test and Evaluation
SAB	Scientific Advisory Board
T&E	Test and Evaluation

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